

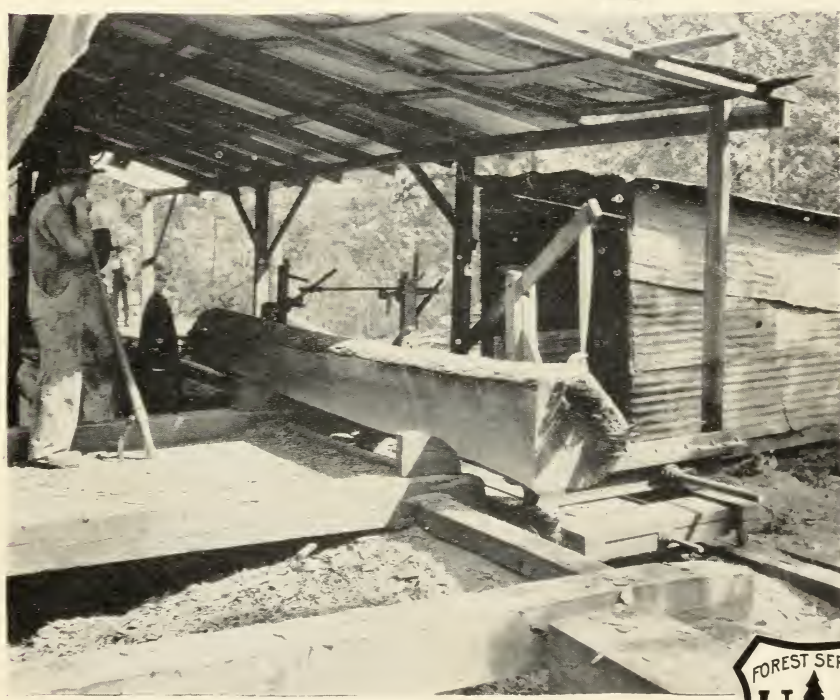
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Operating **SMALL SAWMILLS** *in Wartime*

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U. S. DEPARTMENT OF AGRICULTURE
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Cover illustration.—One of the many thousands of small portable mills, cutting up to 200 M board feet a year. In the aggregate these mills account for a considerable part of the Nation's lumber production. Simple and inexpensive improvements in the equipment and operation of portable and semipermanent mills will produce more and better lumber, bring greater profits to the operator, and often swing the balance from failure to success. Such results are of increasing importance in the country's war effort.

OPERATING SMALL SAWMILLS IN WARTIME

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INTRODUCTION

Small mills play a vital part in expanding production of the lumber needed for war purposes. A large proportion of our lumber comes, and must come, from small mills, especially those in areas near points of heavy consumption for war purposes and with relatively short rail hauls. Small-

¹ Maintained by the U. S. Department of Agriculture at Madison, Wis., in cooperation with the University of Wisconsin.

mill production is as susceptible to expansion as large-mill production, and probably relatively more so. There are evidences, however, that many small mills, instead of expanding, are contracting production. Part of the difficulty is a growing shortage of labor and equipment. This publication suggests how labor and equipment can be stretched to achieve a more efficient production.

Part of the difficulty lies in the dislocation of channels of distribution; that is, small-mill output has been temporarily dammed up by shifting market demands. Normal local farm, home, and industry demands have shifted to nonlocal, special Government demands. These demands are enormous for lumber items that to a large extent can and must come from small mills—for Army trucks, Army beds and cots, boats and ships, war buildings, and housing. Small-mill operators whose previous market outlets have been upset can and should establish contact with the new outlets through lumber-buying agencies they already know about or through their State extension or State forestry departments.

This publication does not deal extensively with the market outlet phase of the situation. Practically all hardwoods are in demand in 4/4, 5/4, 6/4, 8/4, and special thicknesses, particularly in grades of No. 1 Common and Better. All softwoods are in demand, especially in board and framing items, grades, and sizes. Crating and boxing lumber of many species is needed.

The emphasis in this publication is on methods for maximum production with minimum equipment. Treatment of mill lay-out applies primarily to the moving or rebuilding of mills rather than to the installation of new equipment.

According to the published figures of the National Safety Council, the lumber industry has the highest accident frequency of all industries, and these figures do not include small mills. It is highly probable that accidents to workers and equipment in small mills cause as much loss in production as any other factor affecting such operations. The President's proclamation of August 18, 1941, calls on everyone to get behind the National Safety Council's drive to prevent accidents.

FUNDAMENTALS

Save Trucks and Tires.

Conserve the tires you have. Here are six suggestions that may be helpful:

(1) Put the mill close to the timber. A thousand board feet of logs weighs three times, and green lumber nearly twice, as much as dry lumber. Dry the lumber at the mill.

(2) Reserve trucks for the longer hauls over good roads. Tires wear out on rough woods roads three times as fast as on good roads.

(3) Substitute wagons, scoots, or bummers for trucks in the woods. Chutes and streams also can be used in some places.

(4) Repair the bad spots in the roads to save equipment.

(5) Enlist the cooperation of employees in considerate use of equipment, and make yourself or a reliable man definitely responsible for systematic lubrication, tire pressure, and parts checking.

(6) Have minor repairs made promptly; anticipate and schedule major repairs for nonoperating periods.

Cut Trees, Not Saplings.

Mill operators know that each type of operation produces lumber most efficiently when it is operating on trees within certain size limits. The ideal size for sawing with normal small-mill equipment is a tree from 18 to 24 inches thick. But in order to supply his mill the operator frequently cuts sizes which require undue labor per M board feet of output. A crew which can log and mill 1,000 board feet per hour from trees of 20 inches d. b. h.¹ can produce only about 500 feet per hour in trees of 8-inch diameter or less (table 1).

In a typical pine stand as operated by small mills (trees from 8 inches to 20 inches), hourly production decreases approximately 6 percent per diameter inch for trees below 15 inches in diameter, down to and including trees 11 inches. In other words, production is 30 percent greater per hour in 15-inch trees than in 11-inch trees. For hardwood operations, the same general relationship exists.

TABLE 1.—Labor requirements per tree size for a typical small pine mill, in man-hours per M board feet, green rough-lumber tally

Tree diameter breast high (inches)	Felling and bucking	Skidding	Hauling	Milling	Supervi- sion	Total
	Man-hours	Man-hours	Man-hours	Man-hours	Man-hours	Man-hours
8.....	5.63	1.12	2.22	10.30	0.73	20.00
10.....	5.12	1.00	2.17	10.02	.70	19.01
12.....	4.45	.82	2.07	8.83	.62	16.79
14.....	3.65	.60	1.85	7.72	.55	14.37
16.....	3.15	.49	1.67	7.01	.50	12.82
18.....	2.70	.42	1.60	6.60	.46	11.78
20.....	2.37	.39	1.59	6.26	.44	11.05
22.....	2.17	.38	1.62	6.02	.43	10.62
24.....	2.10	.38	1.67	5.96	.42	10.53
26.....	2.18	.40	1.80	6.09	.43	10.90
28.....	2.36	.44	2.06	6.54	.46	11.86
Average.....	3.29	.56	1.79	7.36	.52	13.52

Run the Mill More Days.

The 75- to 100-day annual operating schedule characteristic of small mills in the past can be stepped up with fuller utilization of labor and equipment. For more sawing days and fewer "down" days:

- (1) Take advantage of good weather to log the more difficult areas.
- (2) Keep a greater reserve of logs all along the line from stump to deck.
- (3) Use the labor of a temporarily idle unit (felling, bunching, hauling, milling) for other jobs which promote smooth-running operations.
- (4) Where milling must be seasonal, push the log-making, bunching, hauling, and construction jobs during the nonmilling period.
- (5) Order vital repair and replacement equipment farther in advance of probable failure than you would normally.
- (6) Necessity for using unskilled workers in cutting and handling logs will require careful training and close supervision to prevent accidents. Foolhardy or unsafe practices are too costly to be tolerated in any worker when so much depends on a steady output every hour in every workday.

Cut Long Logs.

Long logs step up the production rate. An estimated 10- to 15-percent increase in production can be achieved by cutting 16-footers rather than 12-

¹ D. b. h. (diameter at breast height).

footers, and a more usable, higher-priced product will be obtained. Only a limited amount of short lengths is allowed in the upper grades; the price per M board foot increases with length in framing and structural items. Check to see if your buckers are making 12-foot logs where they should be making 16-foot logs.

The only valid reasons for making logs shorter than 16 feet are:

- (1) If it is the only way to divide up the tree length to give the best grade yields.
- (2) If in crooked logs judicious length divisions may minimize quantity waste from crooks and short top logs.
- (3) If 16-foot logs cannot be handled efficiently by available hauling or milling equipment.
- (4) If market outlets specialize on short lengths.

Select Saws, Axes, and Wedges Suited to the Job.

Saw lengths should be at least 2 feet greater than the diameter of the larger trees cut. For small timber (15 inches or less) a narrow blade with a concave back facilitates wedging; for larger timber a straight back is recommended. Use the tooth pattern best for the job; hardwood pattern for hardwoods, softwood for softwoods. A 3-pound ax is suited to timber less than 1½ feet in diameter; a 3½- or 4-pound, double-bitted ax for larger timber. But by giving the skilled workman the type of tool that he is accustomed to using, accidents and consequent loss in production will be avoided.

Keep Tools Serviceable.

Very slight departures from precise standards in cutting tools greatly lower their effectiveness. If expert knowledge is lacking, compare the axes or saws with a new one of identical pattern to catch and correct any deviation in profile or other details which results from repeated sharpening. See that the correct pattern is kept sharp and in proper balance.

Encourage Skilled Workmanship.

Under similar conditions, one felling crew cuts 1½ to 2½ times as much as another. That crews take time out to rest is not necessarily a sign of lost time or inefficiency, as the better producers rest about as much as others—an average of 6 percent of the work day. Good production seems to be due to a difference in skills; better planning as to the sequence of trees to minimize waste effort; carefully planned felling to expedite bucking, limbing, and bunching; and more effective application of the tools.

In wide cuts, less effort is needed if the saw cut is moved partly around the face, instead of holding the saw to a single line. Hung trees, high stumps, tears, and splits are evidences of poor workmanship to be corrected by proper instructions on undercut, use of wedges, and the support of unbalanced portions of a fallen tree during bucking. Stump heights as low as 6 or 8 inches for sound trees up to 20 inches d. b. h. lessen waste. Undercuts about one-third the diameter for balanced trees and slightly past the center for unbalanced ones reduce tears and splits, as does the avoidance of excessive wedging to force partly sawed trees. Where splits due to an unbalanced or unsupported condition of the felled tree are likely to develop as the saw works through, support the sagging portion with an upright from bole to ground. In flinty-barked trees—hickory, red oak, etc.—chip off the bark where the saw cut is to be made.

Take time to cut out underbrush and low-hanging limbs so that the sawyer may have a firm footing and the axman a clear space to swing

his ax. Space should be cleared, also, so that the workmen can avoid "kick backs" caused by the spring of limbs as the tree strikes other trees or the ground. Lodged trees are dangerous and should be pulled out with a long steel cable and tractor, or a heavy block and tackle and a team. No attempt should be made to cut the lodged tree free.

Drop trees to avoid bole-shattering obstacles, to permit easy access to succeeding cuts and necessary limbing work, and to leave logs accessible

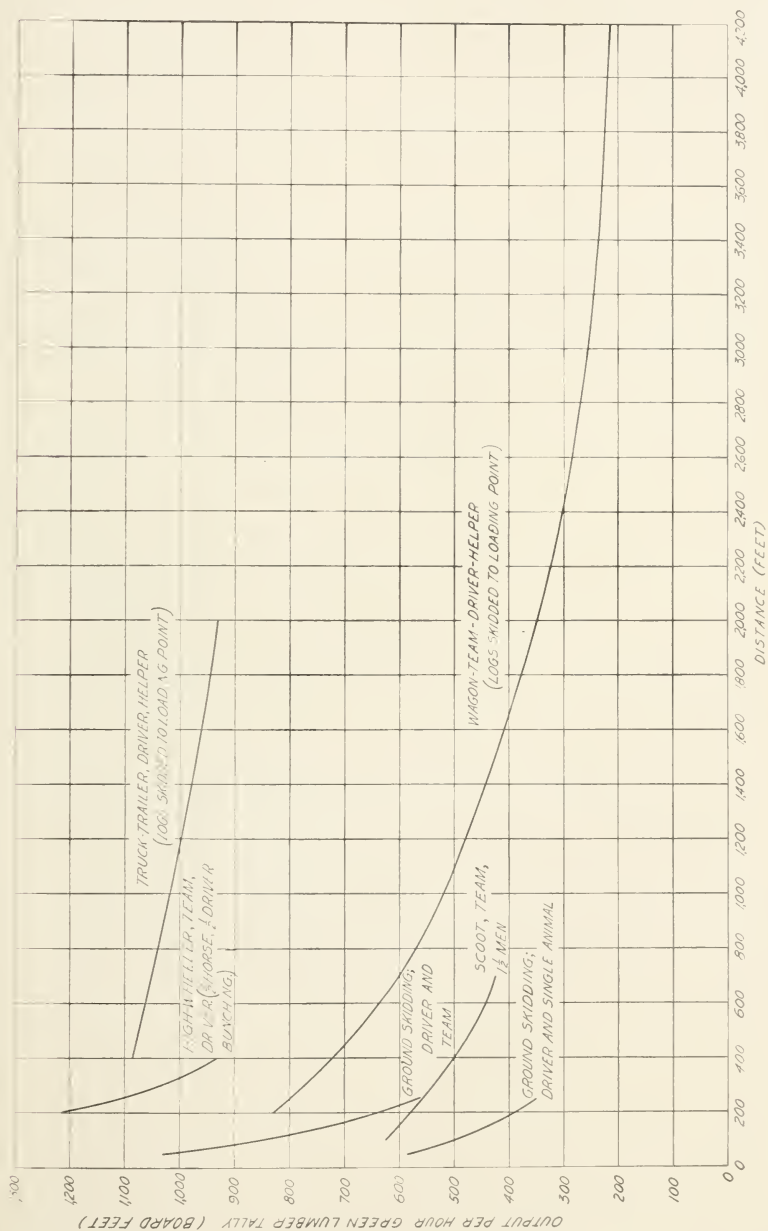


FIGURE 1.—Curves showing the output per hour in board feet (green-lumber tally) at different hauling, skidding, and bunching distances, by different methods of work.

to bunchers. An allowance of 3 or 4 inches in excess of the normal log length is about right to insure correct lumber length.

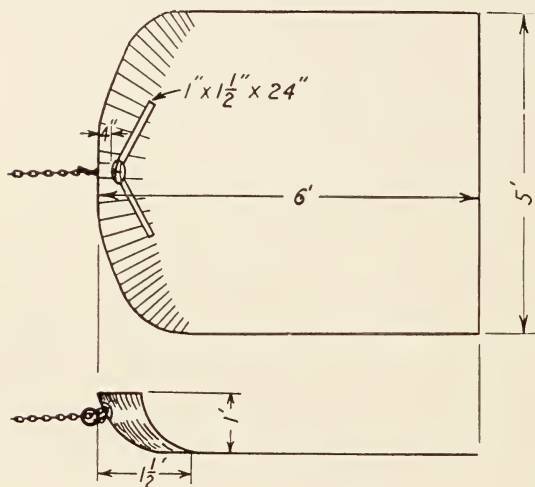
Reduce Delay Time.

Delays other than break-downs are mainly (1) resting, (2) waiting for logs or for other crews, (3) road mending.

Forty percent of the working day in normal small-mill skidding and hauling operations is delay time. Resting, up to an amount of 10 percent for animal units and 5 percent for mechanized units, is an obvious item of delay, but not of greatest importance. Lack of timing is of great importance; viz, the "bottleneck" of a single loading point used by several vehicles on short hauls results in much lost time. Other common bottle-

necks are skidders waiting for logs to be cut, and haulers waiting for them to be bunched—when no reserve of logs is built up. Unless each operation is properly protected, accidents to workers and the crippling of equipment may also cause serious delays.

The dominant cause of delays is faulty road construction (15 percent of the day). Units are idle while drivers or others remove road obstacles. The penalties exacted through decreased output by poor roads resulting in small loads, increased delays, and depreciation of equipment emphasize road-improvement work



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FIGURE 2.—Skid pan for tractor logging made of old boiler plate or other material flared up at front, chained to caterpillar. It is spotted along logs so that when the chains or cables from tongs or chokers are hooked to drawbar and the "cat" is started, the log ends roll onto the pan just behind the flare.

as an indispensable step to more efficient production. They suggest better planning of road locations to eliminate excessively steep, wet, and rough portions. Such measures as the laying of cribbing, poling, and slabs are indicated.

Move Full Loads, Not Overloads.

Capacity loads require no longer to move than undercapacity loads. Light loads are hauled on every job—the same unit from the same area moving some loads that are but one-third the weight of others. Standards of capacity loads, of course, cannot be given for the varied tractive conditions and methods of skidding and hauling, but an increase in production of nearly 12 percent is possible on the normal job through capacity loading. This does not mean overloading of tires or other equipment.

Keep Within Efficiency Zones.

Effects of distance on output by different methods are shown in figure 1. Small operators frequently standardize their crew organization with little regard for the particular logging chance, using, for example, 2 felling crews,

2 skidding units, and 2 wagon hauling units or a truck unit. The figure indicates that, for a small mill cutting 800 board feet per hour, log transport becomes inadequate beyond 200 feet if 2 single-animal units are used; at about 500 feet for 2 team units; at about 1,000 feet for 2 scoots; at 1,600 feet for 2 wagons, and at about a mile for a truck. Thus, in its ability to meet the mill production, a team shows up about $2\frac{1}{2}$ times as effective as the single-animal skid unit, a scoot 5 times, a wagon 8 times, and a truck 25 times. When the cost of operating each of the foregoing units is considered in relation to its efficiency over the single-animal unit, the team is 1.9, scoot 3.0, wagon 2.4, and truck 7.5 times as effective.

Ground skidding is the most costly method of moving logs. The drastic limitations on truck logging will tax the other costlier methods. Operators using caterpillars can increase load capacity (possibly one-third) by the use of a pan made from old boiler plates, which is hooked behind the caterpillar so that logs chained to the drawbar roll onto this pan when the caterpillar is started. This pan is illustrated in figure 2.

LOGGING

Skidding and Hauling.

Skidding and hauling methods must be varied to conform to local conditions. Table 2 gives a summary of the methods more commonly used on small operations.

TABLE 2.—*Summary of skidding and hauling methods, equipment, and conditions of application*

Method	Equipment	Condition of application
Stump to mill direct:		
Ground hauling:		
Animal.....	Logs under 15 inches, 1 animal; logs 15 inches and up, 1 team.	Light loads and short distances.
Mechanical..	Tractor or caterpillar, with or without pans, arches, etc.	Heavy loads and medium distances.
	Truck or wagon and team.	Light logs accessible to vehicle and boosted to load by manpower. Short, medium, and long distances.
Vehicular hauling.	Sled, team.....	Light and heavy logs accessible to vehicle and rolled on skid to bunk. Short distances.
	High-wheeler, team....	Any size, accessible to vehicle. Short distances.
	Bummer, team.....	Do.
Bunching and hauling:		
Bunching.....	Either ground or vehicular equipment above.	
Loading:		
Hand.....	1 or more helpers with peavies and driver.	2 or more men roll logs upon vehicle. Suited to conditions where logs start from bunk level as banks or decks.
Cross haul...	Team, chains, skids, helper.	Team on chain looped around log pulls it up skids. Suited to normal range of log sizes elevating from ground to load positions. Needs little advance preparation but unsuited to loads confined by stakes.
Block and tackle.	Spars, pulleys, cable, chains, grapples, team or power unit, helper.	Log lifted and placed by cable working through blocks, 1 man manipulating the hooks, another servicing the power. Permits placing all sizes in well-balanced loads within stakes with minimum shocks to vehicle.
Hauling.....	Truck or wagon and team.	Efficient on level and moderately sloping terrain over firm and uniform surface.
	Sled, team.....	Readily available, cheaply loaded, and used on steep downslopes or rough terrain to better advantage than wheeled vehicles over bare ground; and in all snow logging terrain unless auxiliary equipment is available to keep roads passable for wheeled equipment.

Under all such conditions, it is well to keep in mind the savings of time and expense that are possible through avoidance of accidents. Rolling and sliding logs, particularly in work on steep slopes, are highly dangerous, especially to untrained workers. Skidding, decking, loading, and unloading require careful supervision, especially in the use of cant hooks, peavies, block and tackle, and gin poles. Probably the most dangerous operations are high decking on trucks and sleds and hand rolling of logs.

Mountain Logging.

Here substantial road development is usually confined to the main drainage channels, logs being skidded to rollways. Steep skid trails permit

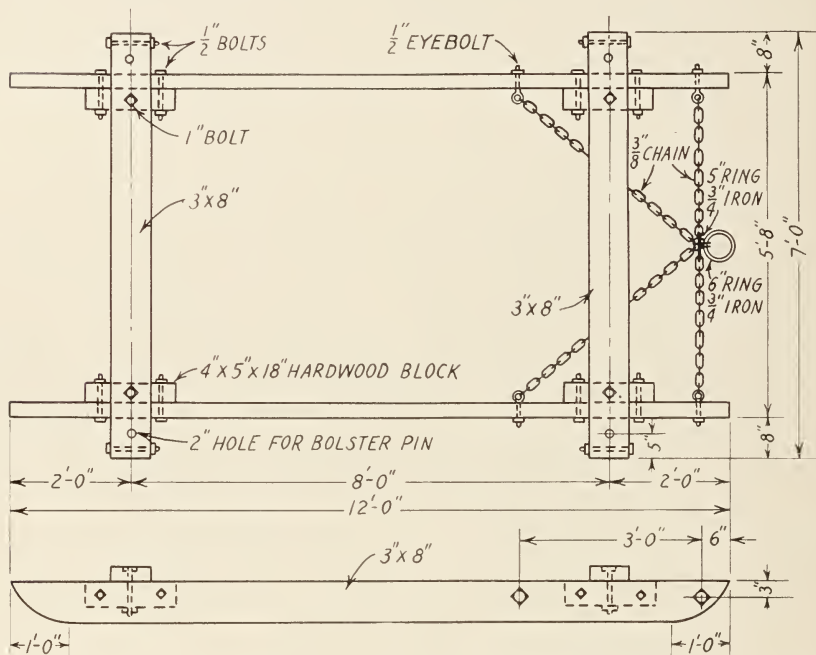


FIGURE 3.—Scoot or sled for team logging on gentle to steep down slopes.

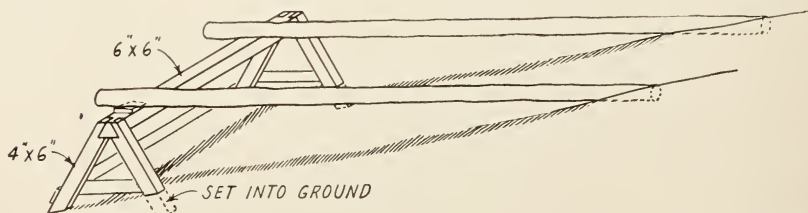
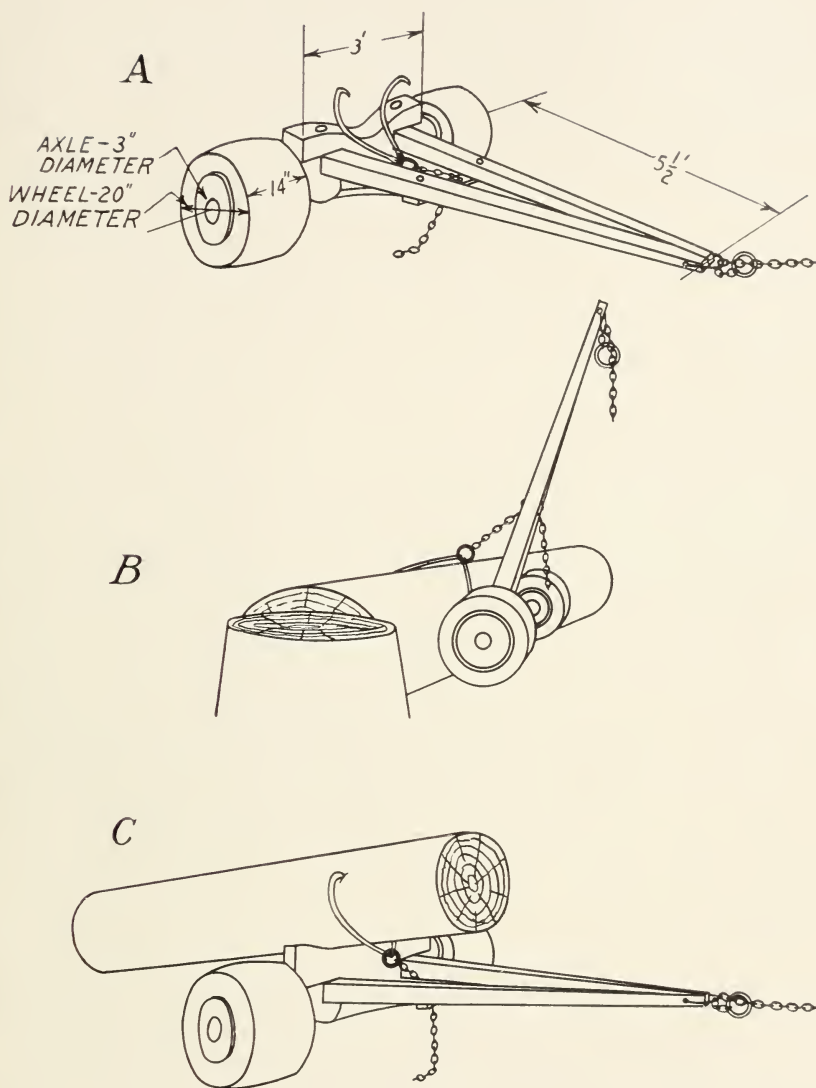


FIGURE 4.—A portable dock saves labor on rolling ground. The "horse" support is placed parallel to where the vehicle rests (trenching the truck wheels slightly may help in placing the truck accurately in position). Lay skids from ends of bolsters, across the horse and over to the upper slope, so that they are about horizontal. After loading, another truckload can be rolled onto the skids ready for the return of the truck.



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FIGURE 5.—Specifications for a home-made bummer, for team logging on level-to-rolling land. The wheels (A) can be made from sections of a tough, shock-resisting log (blackgum or elm), axle from shafting, tongue and bolster from oak or hickory. The chain from the tongs is keyed to the tongue cross-bar. To load, back bummer against log (B), elevate tongue, and hook tongs about 3 feet from log end. A chain 8 feet long between whiffletrees and bumper tongue makes this possible without unhooking the team. Start the team so as to bring the tongue straight down; then swing ahead of the log, pushing it into the saddle of the bunk (C)

skidding of relatively heavy loads, several logs being connected in a line by grabs. Skill is required in laying out the skid trail to avoid pitches where logs get out of control, sharp turns, and level stretches where they are hung up. Skilled teamsters are vital. Load-out points get sufficient

footage to warrant cribbed deck skids if hand loading (short haul) or tackle (long haul) is used. Alternative skidding methods are to sled over bare ground on downhill hauls from stump to deck, or to pull with a "cat" a series of logs previously bunched by team at the trail. Very rarely small operators pull uphill with winch and cable logs previously team-skidded to a bunching point.

Logging on Rolling Terrain.

In medium and large timber on small operations the caterpillar or tractor is used increasingly. Pans, sleds (fig. 3), or arches increase the load-hauling capacity and thus the distance effectively covered. On a haul that is mainly downgrade, a driver and normally one helper move logs from stump, usually less than a mile, to mill or landing.

In either large or small timber, team-sled hauling on bare ground is effective for short distances and downhill hauls. Where possible trees are felled in windrows up and down the slope. The load is made up, in progressing down the windrow, by the driver and helper rolling the logs over short skids onto the bunk. High-wheelers are effective for large and medium timber over short distances. The vehicle is driven astraddle the logs which are then suspended clear of the ground or partly so under the axle. High-wheelers can negotiate relatively rough ground.

The widely used method for logging on a rolling surface is a combination of skidding and hauling. In one case a teamster and helper skid and load with the cross haul, using the hauling team. Only enough logs for the immediate load are skidded to the wagon, so that skid distances can be kept short where wagon access is possible over the area. In another case, a separate skid crew bunches the logs. This crew may also cross haul to load the truck or wagon, or logs may be hand-loaded, or by block and tackle. Skid distances can be kept short by establishing frequent loading points. A labor-saving portable dock can be used to advantage on rolling surfaces and for light loads where hand loading is used (fig. 4). Heavy loads (long-distance hauling) bring into use block-and-tackle loading devices. Usually the skid haul is substantially lengthened because of the smaller number of loading-out points.

Logging on Flat Terrain.

The same methods outlined for rolling terrain are used on flat land, except that sled hauling over bare ground must be omitted and bumper hauling added. Bumpers are used mainly to bunch medium to large logs and for short hauls. Specifications for a home-made bumper are shown in figure 5.

MILLING

Time studies show that small mills actually operate about three-fourths of the day. Of the time lost, two-thirds is due to avoidable delays, such as fixing machinery, waiting for logs, steam, and the like. Delays for repairs can be greatly reduced by the use of serviceable, properly installed equipment systematically checked and serviced.

Serviceable Equipment.

Equipment to be serviceable should be balanced for the job. Light mills (3,000 pounds, 25 horsepower), efficient on logs under a foot in diameter, are overloaded and underpowered for larger logs. Slowing the feed for thick cuts reduces production, overtaxes power units, and wrecks the equipment, with consequent excess wear, "miscuts," and breakdowns. Medium-

weight mills (4,000 pounds, 50 horsepower) are efficient on logs under 20 inches. In larger timber, the heavy type of small mill with top-saw attachment is needed.

The relation between saw diameter and the log diameter which can be sawed by the standard method of "sawing around" the log is as follows:

<i>Saw diameter (inches)</i>	<i>Log diameter (inches)</i>
48	28
52	30
56	33
60	36

A double-acting networks, with a cut rather than cast ratchet and a spring or friction receding mechanism, permit rapid, accurate knee adjustments. For sawyer-operated networks, dogs with the lever arm alongside rather than behind the knee are more convenient. With a man riding the carriage, the lever arm is behind the knee, and Knight dogs with a single lever connected to two or more sets and supplemented by a couple of spiked dogs can be speedily operated. Roller bearings on saw mandrel and carriage wheel contribute greatly to smooth-running mechanism.

Belt failures on feed mechanism and sawdust-chain breakage are two common causes of delays. The correction is to increase belt width (at least 1 inch) if there is space for suitable pulleys and to get heavier sawdust chains or a blower.

Good mill equipment is nullified by inadequate power. Headsaw power requirements bear a close relationship to log size and wood density. Approximately $2\frac{1}{2}$ times as many teeth work at a time on a 20-inch cut as on a 12-inch cut. Heavy species are twice as dense as light ones. Large, dense logs require 4 or more times the power needed for small light ones. Small mills should have enough headsaw power to make $\frac{1}{12}$ -inch sawdust—each 12 teeth should cut an inch along the log—in the average cut taken.

Much time can be lost in accidents through the operation of the sawing unit. Insistence on the following practices will save much of this loss:

1. Moderate piling of logs on the deck serving the log carriage.
2. Separate piling of logs with flat sides, large knots, and crooks, to avoid jams.
3. Use of cant hooks at all times to roll logs.
4. Keeping walkways clear of bark and other obstructions.
5. So blocking the log carriage that logs cannot move unexpectedly as new logs are placed or turned.
6. Keeping down hazard from flying dust, splinters, or pieces of bark.
7. Placing deck far enough from headsaw to avoid possibility of any worker near carriage and skids tripping and falling into saw.
8. Shutting down saw when oiling or other work is necessary around it, and shutting down when belts are being replaced.
9. Wearing gloves to avoid splinters.

Setting Up a Ground Mill.

Carelessness in locating, installing, and lining up equipment brings penalties in subsequent delays, and mismanufacture.

In choosing the mill site, two general requirements are:

1. Place the mill so as to minimize logging up hill and to favor hauling out lumber.

2. Have the machinery on relatively level ground combining, if possible, gentle slope at the log deck, sharp downslope to the refuse burner if slabs and edgings are burned, and level or downhill haul to the yard in case lumber is dried at the set-up. The drying lumber should not be in a depression where free air movement is blocked. If steam-powered, a suitable water supply becomes an essential.

The three essentials in setting up a ground mill are:

1. Have the mandrel level.

2. Have track level at right angles to mandrel and so bedded that carriage headblocks clear the saw by $\frac{1}{2}$ to $\frac{3}{4}$ inch at a line approximately 1 inch above the saw collar.

3. Have track and husk so bedded and bolted as to hold this relationship under the shocks and stresses of sawing.

Place the husk at desired location and lay a sill under each end, to permit accurately bolting husk to sills, allowing sills to extend parallel from beyond the outside track to the pulley end of mandrel. Sills should be at least 10 by 10 inches, well-dried heartwood of durable species. Mills differ as to methods of locking husk to sills. Some use metal plates or angle irons, others bolt the husk directly to the sills. Husk and sills should have no play under the heavy stresses of operation. Mortising plates into sills and dressing the face at contact with husk further this in some types.

Mark on the ground the outline of sills and saw pit. Bed sills firmly about half their depth so that the husk is level both ways. Use a level to determine this. See that sills are solidly supported their entire length with ends under outside track, each resting on a post driven solidly into the ground, and tamp earth firmly against sides. Dig saw pit ample to provide for type of dust removal and feed works employed.

Bolt husk firmly to sills, and place mandrel and feed works.

Portable mills are usually provided with light metal tracks fastened to light stringers, and correct track width is maintained by cross pieces between stringers. These stringers rest on ties which in turn rest on sills bedded in the earth. The gap in the sill-tie foundation at the saw pit should be reinforced with 6- by 8-inch cross pieces saddled between the husk sills directly under each track. Good foundations for the track beyond the saw pit are assured by bedding under each rail a 4- by 6-inch sill leveled with the top of the husk sills.

The mill manufacturer patterns the drum shaft and track stringers to insure that the headblocks clear the saw by $\frac{1}{2}$ to $\frac{3}{4}$ inch at a line about 1 inch above the saw collar. In some mills this $\frac{1}{2}$ to $\frac{3}{4}$ -inch clearance is fixed by metal plates between husk and track. Lacking these, fit blocks between the husk and rail stringer, one bolted to each sill. Bolt track stringers tightly to husk sills and ties, making sure that track is at absolutely right angles to mandrel and level both ways throughout its length. Tie in other track sections, maintaining those conditions.

Place carriage on track and run it the length of track, testing with levels lengthwise and across the headblocks to check accuracy of leveling. If inaccuracies occur, correct by raising or lowering sills under ties. Fasten one end of cable to cable eye on front of carriage, and run cable through deck-end pulley and back over drum. Usually the first strand is carried over the top of the drum and from 3 to 5 wraps taken on the drum, the cable leaving the drum at the top. These wrappings should occupy the middle portion of the drum. Thread cable through other pulley and fasten to eye at rear of carriage. The cable should be tight when fastened.

Mills naturally wear with service and therefore may give a poor performance even when carefully set up. Mandrel bearings, carriage wheels, setworks, and headblocks should be checked. The mandrel should run level and without end play, which calls for good bearings. The same is true of carriage wheels. Provision is usually made for taking up play developing in carriage wheels. Keep the wheel adjusted just short of binding or sticking. Worn setworks parts preclude accurate cutting as do worn bolsters on headblocks.

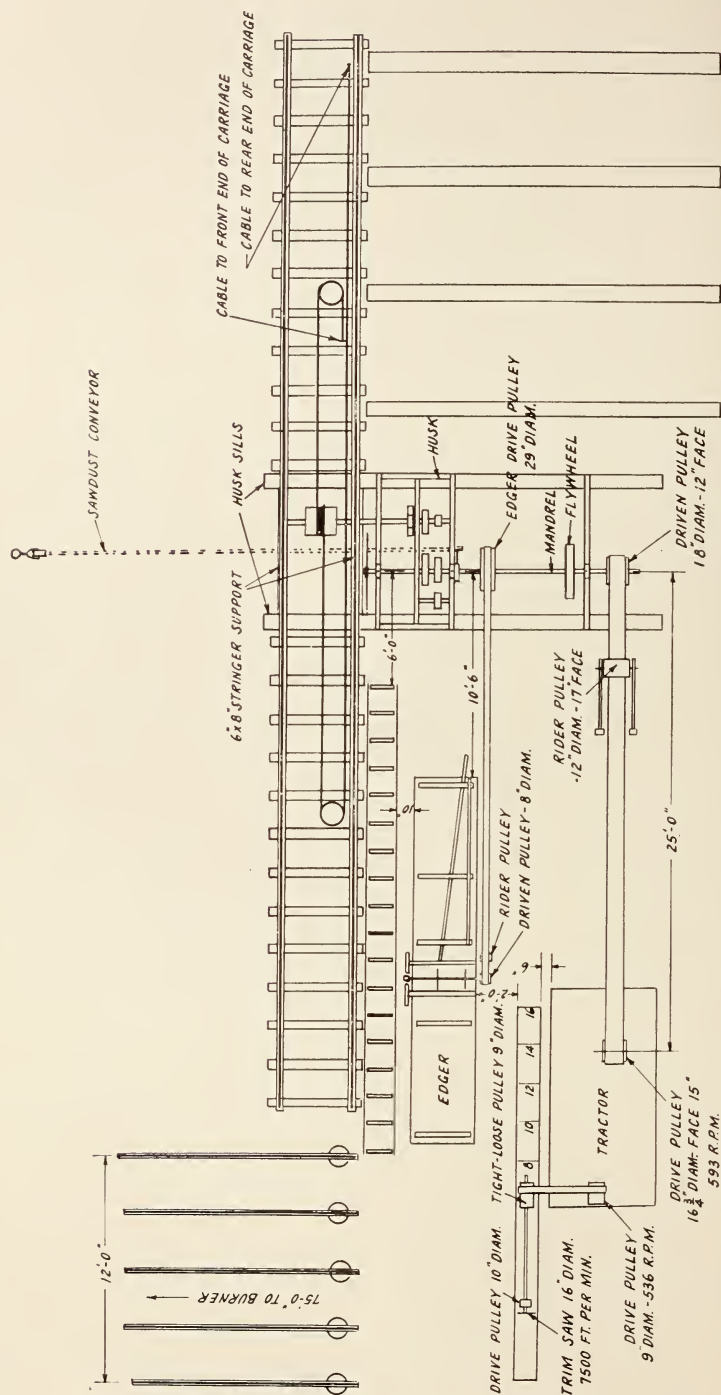
Fasten the guide blocks to husk adjusted so that guide pins touch the saw about $\frac{1}{4}$ inch inside the gullet to clear bit holders and 2 inches below level of carriage bolsters on the front or deck edge of saw. The board side pin should be set even with the face of the fixed collar by placing a straight edge across the face of the fixed collar and bringing pin to straight edge, fixing guide block firmly to hold this adjustment. The log side pin is set after putting lead in saw.

The next step is to hang the saw. It must fit the mandrel perfectly, not so tight that it must be forced on or loose enough for perceptible play. Place loose collar and tighten lug pins or screws. Tighten nut hard against collar and check with plumb line to insure that saw is vertical and not dished. Minor dishing can be corrected by inserting paper shims. Cut one paper ring $\frac{1}{2}$ inch wide and of the full diameter of the collar. Cut a second ring $\frac{1}{2}$ inch wide and of a diameter to fit inside the hole in the first. Oil both paper rings and stick larger on fast collar and smaller on loose collar if dish is away from log; reverse if dish is toward log. Additional rings may be used if required, but guard against reversing dish.

Next, put the lead in the saw. This is done by slewing the mandrel slightly in a horizontal plane by means of set screws controlling this adjustment, so as to bring the front edge of saw slightly into log. Be sure mandrel does not bind in bearings after adjustment. Try a $\frac{1}{8}$ -inch lead in 20 feet and if saw heats at the rim reduce this. If it heats at center, increase lead. A simple means of getting a $\frac{1}{8}$ -inch lead in 20 feet is to bring the carriage so that the rear bolster is opposite saw center and fasten a strip along top of bolster to project within $\frac{1}{8}$ inch of the saw. Run carriage 20 feet from saw center toward deck and stretch a line from end of strip across face of saw. Adjust mandrel until the string tautened in a straight line touches both edges of saw along log-side face. Set board-side guide pin to saw in new position and, when saw is running, set log-side pin close enough to steady but not bind the saw. Attach spreader wheel behind saw to clear the teeth about $\frac{1}{2}$ -inch and in same plane as saw, but not so that it rubs the log.

There remain the installation of log deck and power unit and possibly of lumber rolls, edger, cut-off saw, dust conveyor, dip tanks, shelter, and yards. A simple log deck can consist of skids to facilitate easy approach of log to carriage. A gentle downslope to the carriage is helpful though not essential.

The power unit (fig. 6), if hooked up by means of a flat-belt drive, should be so placed that the driver and driven wheels are about 25 feet apart, their mandrels truly parallel and pulleys in line, the belt centering on the pulleys. Do not use guides to keep belt centered. Space units so that the belt has about a 4-inch sag on slack, or top, side. Place belt rider on top of the slack belt. For edger driven from headsaw mandrel the lower belt is slack. Place rider on under side of lower belt and close to small driven pulley on edger.



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FIGURE 6.—Plan showing the distribution of the power unit in a typical small mill.

Portable mills sacrifice power to mobility and cannot maintain high speeds in feed and saw. Tractor-powered mills run idle with a rim speed of saw approximating 7,000 feet per minute, falling quickly as the saw enters the log. On a wide face the saw can be practically stopped. The sawyer attempts to vary the feed in order to maintain this lower speed uniformly under load. To attain good production, a mill of this, type should, up to a 12-inch width of cut in softwoods, stand a feed which cuts a 16-foot line in as many seconds as the face is wide in inches and hold a rim speed of 5,500 feet per minute.

Lay-outs and Sheds for Small Mills.

Operators cutting up to 200 M board feet at a set customarily spend about \$50 for moving and installing equipment, put the mill directly on the ground, and provide little or no shelter. Such a mill is illustrated on the cover of this publication. With a cut of between 200 and 1,000 M board feet, the installation costs may be up to \$300 as a result of erecting a simple shelter. The equipment is usually on the ground or on a floor at ground level.

Housing a mill of this size in one of the simple shelters described in plan 1 or plan 2 below, will insure more sawing days, fewer delays, greater comfort to workmen, and longer life of equipment. Plans 1 and 2 both apply either to tractor- or steam-powered mills cutting at least 200 M board feet at one site. Plan 1 differs from plan 2 in that it provides for a dip tank, an inclined slide instead of trucks to carry refuse to the burner, and a wood instead of a corrugated-iron roof.

With a prospective cut of more than 1,000 M board feet, an expenditure up to \$1,000 in building and installation is justified. Such mills are equipped to produce between 1 and 2 M board feet per hour with a minimum of labor. Plan 3 gives specifications for such a lay-out.

Plan 1.—This shed (fig. 7) can be built with about 9 M board feet of lumber. Side and end elevations for two methods of roofing the structure are shown. Gravity will carry slabs and edgings to the fire if the location permits erecting a slide having a 1-foot fall in each 2 feet of horizontal distance. Rails are either unsupported for the 12 feet nearest the fire or metal supports are provided.

Plan 2.—This shed (fig. 8) requires about 4 M board feet of lumber, exclusive of trestle, and 1,650 square feet of corrugated roofing. Substituting wood for the now unobtainable corrugated roofing will require a higher pitch and some 2,000 more feet of lumber. In this lay-out slabs passing over dead rolls are loaded on a small car and, together with edgings, are run out about 75 feet and dumped so as to slide 20 feet down five inclined rails to the fire. Lumber loaded on another car is run out to piles over a separate track. The columns supporting the trestles are placed in pairs at 8-foot intervals and are joined with 2- by 6-inch caps. In the event that a relatively small portion of the material goes through the edger, the rolls are omitted and the lumber car brought within 6 feet of the head-saw, in line, so that sawed boards and slabs fall to the car, the slabs being carried across the carriage tracks and loaded on a slab car outside the mill. The floor of the slab car is supported by a single beam lengthwise along the middle. The beam has beveled ends resting in notches so that it pivots as the load is dumped. One end of a chain is permanently fastened to the car floor and the other temporarily to the truck body to prevent pivoting prior to dumping.

In both plans 1 and 2, the 4- by 6-inch joists supporting the mill floor are spaced about 3 feet apart, but care should be taken to have a joist directly under the breaks in the carriage track. It is advisable to provide for a roomy sawdust pit under the headsaw (at least $3\frac{1}{2}$ feet from saw rim to bottom of pit) and one under the edger large enough (6 feet deep by 4 feet wide) to permit a wheelbarrow to catch sawdust directly. For steam-powered mills the engine would be mounted in the space labeled "tractor" and the boiler set up preferably accessible to the slabs on the opposite side outside the mill at the rear.

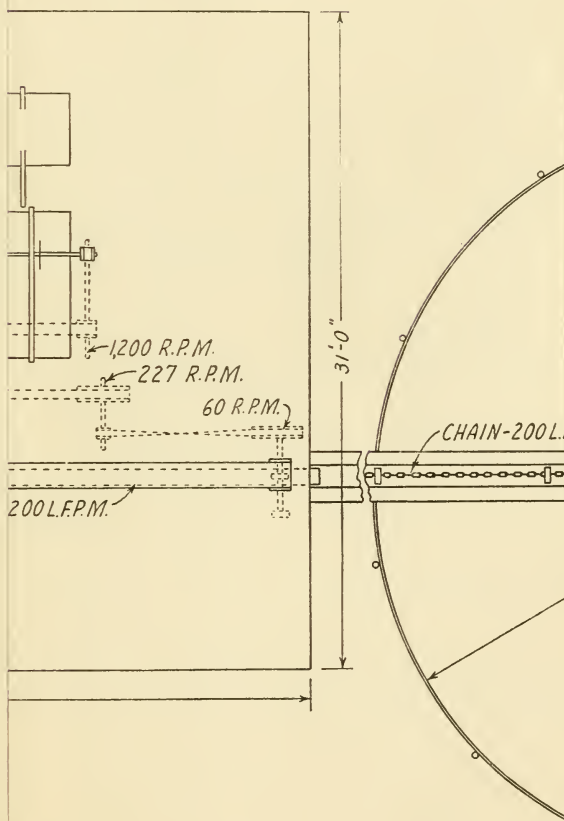
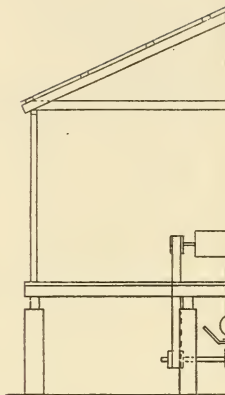
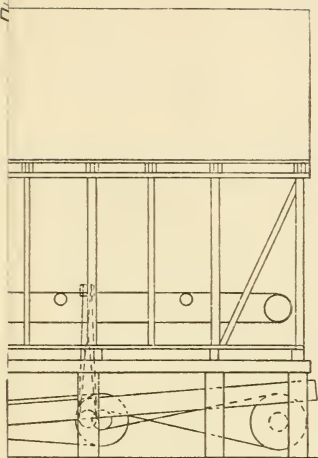
Plan 3.—This semipermanent mill (fig. 9) is supported at least 4 feet off the ground by a series of piers at 6-foot intervals for the length of the mill, with a spacing of 8 feet between individual piers across the mill; except that the five series at the front of the mill to the saw are spaced 4 feet between individual piers (see end elevation). A plank floor is continuous, except that the power-unit base rests on the ground and the space over the unit and drive belt and to the log haul-up mechanism is unfloored and may serve as a saw-filing space. A blower delivers sawdust from the headsaw and edger; and a conveyor belt delivers slabs and edgings to the refuse chain at the rear of the mill and thence to the burner placed at least 75 feet from the mill. The lumber after passing through the gravity dip tank is piled for transportation to yard or elsewhere outside the mill opposite the tank. The crew consists of at least 7 men as follows: One man to haul up logs, a deck man, sawyer, tail sawyer, tail edgerman, trimsaw operator, and pile-out man. The equivalent of 100 h. p. diesel should be used for power. Approximately 11,000 board feet of sawed material, 2,500 board feet for piers, and 2,400 square feet of roofing are required.

The plan is drawn to scale. Pulley sizes are based on the assumption that the drive pulley to the headsaw has a diameter of $17\frac{1}{2}$ inches and that to the intermediate shaft 20 inches, each turning at 1,000 r. p. m. The suggested speeds for various pieces of equipment are: Headsaw, 650 r. p. m.; log haul, 100 lineal feet per minute; edger saws, 2,000 r. p. m.; blower, 2,800 r. p. m.; trim saws, 1,720 r. p. m.; slab-conveyor belt and refuse chain, 200 lineal feet per minute.

The drive shaft on the power unit is $3\frac{1}{2}$ inches in diameter, the intermediate shaft is 3 inches, the blower shaft $1\frac{7}{8}$ inches, the trim saw and conveyors 2 inches. The drive belt to the headsaw should be at least 12 inches wide, to the intermediate shaft 10 inches, from intermediate shaft to trim-saw shaft 8 inches, from trim-saw driver pulley to drive belt 6 inches, from intermediate shaft to second intermediate and all belts beyond for conveyor transmission 6 inches, from intermediate shaft to edger 8 inches, from intermediate shaft to blower 5 inches. The belt conveying slabs is 15 inches wide and the logs in the trash conveyor chain are spaced 8 feet apart.

Log Breakdown.

The most advantageous method of sawing logs on any operation depends upon market demands and the price differences between different grades and between thicknesses within a grade; also upon log size and quality and mill capacity and facilities. Thick stock of the better grades normally brings a better price than inch lumber, and for several war purposes is in stronger demand. In hardwoods (grade on the poor face) the likelihood that the grade on the inside face will hold up to that on the outside decreases, of course, as thickness increases; hence to capitalize successfully on thick stock requires expert knowledge by the sawyer. Also, to dry



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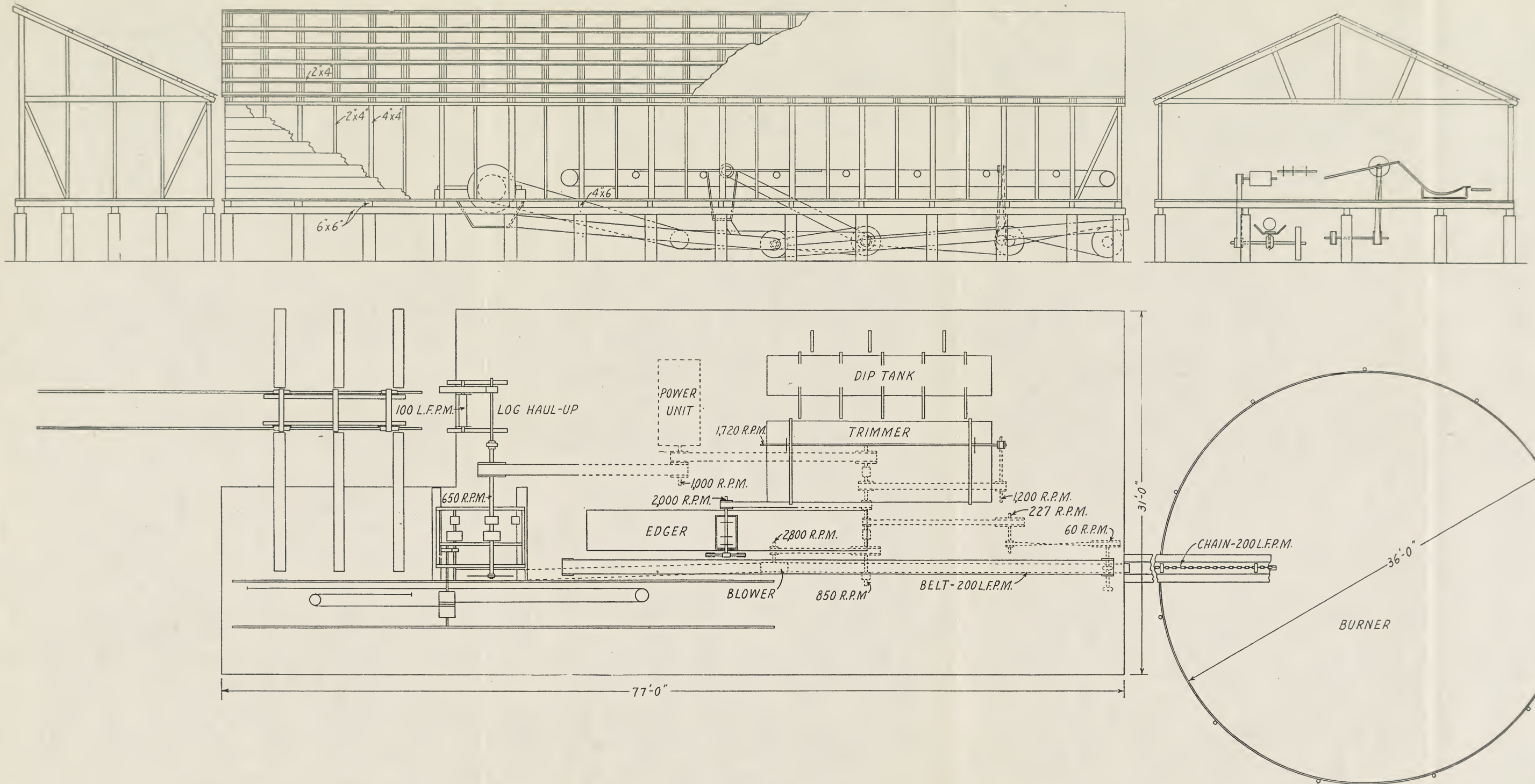


FIGURE 9.—Plan of a semipermanent small mill where the prospective cut is 1,000 M board feet or more. Capacity is 1 M to 2 M feet per hour, with a considerable saving in labor in proportion to the smaller mills already shown.



thick hardwood stock properly calls for special precautions. Sawing for maximum grade and value has one limitation. The small sawmills that depend upon air drying must keep within reasonable limits in the number of separations of material they make that require separate piles in the yard. A complete separation of several items by species, grades, thicknesses, lengths, etc., results in a high percentage of the daily production exposed and seriously damaged by too rapid drying on the top course of unfinished piles. The No. 1 Common grade for inch lumber of many softwoods is not readily marketed, whereas the thicker items in this grade are in demand.

The following method is somewhat standard for breaking down logs, but subject to variation in line with local requirements. In straight logs with little taper, saw the best face first. Crooked ones are usually placed on the carriage with an eye to most effective dogging; that is, the bow down or up. Given more than one good face, saw the poorer one last.

If power-turning equipment is lacking, the large logs are usually turned down a quarter turn after completing a face; in this way logs with one poor face are placed poor face down for the first cut. Large logs with two poor faces opposite are started with a poor face down and turned up a half turn after cutting the first good face.

Taper-saw the good faces by setting out the small end until a board of minimum merchantable width for the upper grades can be taken the full length of the log. Cut boards for the first one or two lines to minimize edging waste, then continue until the grade drops below a standard, such as No. 1 Common, taking either 4/4 or thick stock as inventory requires. After taper-sawing a face, the taper offset is withdrawn, then either (1) the small end of the log is set back against the knees and the face square-sawed parallel to the opposite face, or (2) squaring may be done in slabbing the opposite face or (3) squaring may be done just before finishing the opposite face.

In the case of one good face or two adjoining good faces, taper-saw the good ones and square in slabbing the opposite ones.

If there are two good faces on opposite sides, taper-saw the first, then taper-saw the opposite one and square before turning away from the second face by withdrawing the taper offset and setting the small end back against the knees. Usually one or more short boards can be taken in squaring up, but the tapered end of this stock must be trimmed.

On poor faces not taper-sawed, slab to expose the minimum width and length merchantable and cut boards rather than thicker stock until far enough into the log to minimize edging waste.

The distance between the bottom and top faces after the final turning is the width of succeeding cuts. Therefore, if these must meet definite width requirements, the sawyer must anticipate this in squaring up the cant. Also to be anticipated, after the final turning, is to end up with an item of standard thickness from the last or "dog" board.

Small logs of a quality yielding common grades are turned up a half turn after sawing the first face, and sawed completely without further turning or again turned up a quarter, sawed, and turned up a half, and finished. Variations of these methods and special techniques for special-purpose sawing are often used.

Thickness Standards.

Inaccurately cut lumber is a universal source of waste. Lumber must meet the very definite size standards given in the official lumber grading

rule books of the lumber association concerned with the species in question. The problem in milling is to allow correctly for drying, shrinkage, and sawing inaccuracies. A guiding rule to cover shrinkage in air-dried lumber is to allow $\frac{1}{32}$ inch for each inch of thickness or width of the item. Thus if the standards prescribed $\frac{2}{32}$ as the softwood minimum rough, air-dry thickness, theoretically the set-works could be set to cut $\frac{15}{16}$ inch. In hardwoods, with the rough, air-dry base of $\frac{3}{32}$ inch, the set-works theoretically could be set to cut $\frac{3}{32}$ inch. Actually, a mill is usually able to cut about one-fifth of its boards within the $\frac{1}{32}$ -inch class set for, the remaining four-fifths vary up to and beyond $\frac{1}{8}$ inch each way from the set-for thickness. Instead of setting at $\frac{15}{16}$ (softwoods) or $\frac{3}{32}$ (hardwoods), it is a good mill which can set at $\frac{3}{32}$ in softwoods and $\frac{37}{32}$ in hardwoods, and place every board within the minimum thickness standards for nominal inch lumber.

Sawing Accuracy.

The main causes for inaccurately cut lumber are: (1) Faulty condition of the saw, such as uneven filing of saw teeth, excessive or uneven swage, dull teeth on one side, unequal or incorrect tension; (2) worn bearings in mandrel, in carriage wheels, and particularly in the setworks; (3) poor installation of carriage and saw, chips between log and head block or on the tracks; (4) careless setting, inadequate manipulation of the dogs, miscalculation; (5) frozen timber, or unusual stresses in the wood.

Adjust the saw, carriage, and track for accurate work, then check to determine whether the more accurate lumber can also be made thinner. A suggested check is to measure 100 freshly sawed, nominal $\frac{1}{4}$ -inch boards to the nearest $\frac{1}{32}$ inch at the thinnest place (take measurements 2 feet from each end and at middle point). This record should indicate if setting for a thinner thickness is practicable. Approximately 1½-percent increase in outturn results from each $\frac{1}{32}$ -inch reduction in thickness for a mill mainly cutting inch lumber.

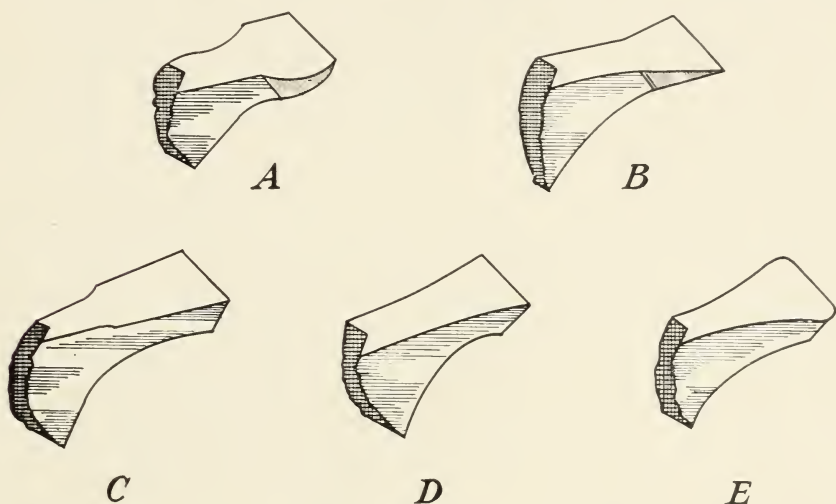
Saw-tooth Standards.

On small mills the sawyer usually services the headsaw. A time-saving suggestion conducive to uniformly sharpened teeth and as a substitute for hand filing is the purchase of small hand-power equipment of the type which is clamped to the saw so as to bring an emery wheel against the face of each tooth at the same angle. Either hand or machine sharpening should result in all teeth being exactly patterned to a precise standard.

This standard varies in details to meet job requirements, but some universal recommendations can be given. All cutting edges should be precisely of the same width and height. Do not mix used and new points; there may be approximately $\frac{1}{32}$ -inch difference in width (kerf) and $\frac{1}{32}$ -inch in length (height) in a new and old point. The cutting edge should be level and straight, conforming to a horizontal line at right angles to the plane of the saw blade.

The corners of the cutting face are varied in pattern for different types of cutting, but must not vary on one saw. Corners normally wear down first. Obviously corners shaped like *A* and *C* in figure 10 resist wear more than those like *B* and *D*, but are less capable of clean cutting. Experience demonstrates that the *B* and *D* type of corners are needed to counteract "fuzzy" sawing in certain species (cottonwood, basswood) or to knife through stringy inner bark, whereas the *A* type can be used for very knotty material. Any approach to the rounded corners of the *E* type must be avoided.

The type of corner and shank edge below the corner is somewhat tied in with the amount of swage. The swage or width added to the cutting edge in excess of saw-blade thickness should be the least needed for blade clearance (a cool-running saw). The probable reason for a greater swage for some softwoods as compared to some hardwoods is that the fibres of the former are not so cleanly severed as those of the latter, and are more prone to close up the clearance space. A second reason for the greater swage for some softwoods is that hardwoods or frozen timber usually put a greater load on the saw, and sawyers slow up the feed to the degree that



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FIGURE 10.—Saw-tooth patterns: *A* and *B*, solid-tooth patterns; *C*, *D*, and *E*, insert-point patterns.

resulting sawdust is fine enough to escape the gullet and fill the clearance space (saw heating). Reducing the swage cuts down slightly the load of dust packing.

SPECIAL LABOR SAVERS

Decking.

A system of hauling logs to the deck by power by a drum-cable-car hook-up is shown in the plan for a semi-permanent mill (fig. 9). A drum-cable-spar hoist can also be used advantageously.

Home-made Deck Log Turner.

A simple log turner to save time and labor on medium and large logs can be made on the job (fig. 11). The three deck skids have an overall spacing of $11\frac{1}{2}$ feet, and the first is 8 feet from the saw mandrel. The turner is seated in the first two skids so that the flat face is slightly below the skid top when the turner is not in use. The sawyer elevates the arc of the turner by placing his foot on the iron lever arm and forcing it down a quarter turn, whereupon the deck man turns the log down against the arc, forcing it back toward the knees as the turner revolves back to its original position. The metal strip used to face part of the arc should be adjusted to serve also as a counterweight, to insure that the turner rests below skid top level when not in use.

The wooden arcs are 4 inches thick with a radius of approximately 1 foot, partly faced with the metal strip, and fastened to the 4-inch pipe axis with a bolt as shown.

Moving of Slabs and Lumber.

To keep the mill from choking up at the rear frequently requires a lot of manpower; that can be avoided by the use of trucks and slides as indicated in plans 1 and 2 on page 17.

Lumber-Truck Loaders.

Several methods which permit more orderly handling of lumber at the rear of the small sawmill warrant more general adoption. Depending upon production volume, one or another of these methods appears well suited to various types of small mills. These methods are in addition to the one described under Lay-outs and Sheds for Small Mills which has proved effective where neighboring and small yards do not require extensive trackway.

Lumber prop.—Mills built directly on the ground can use the lumber-prop method, which permits grouping of items by species, thickness, width, length, or grade at the mill instead of at the pile. A series of rolls carries the lumber out the rear of the mill, and one man piles it, by required items, on special props (fig. 12). Spacing between props should be adequate to permit backing the wagon truck or bumper under the load; the prop is just high enough that the vehicle's bunk contacts the load about an inch ahead of the prop, the prop itself being placed about one-third the length of the load from the front end. About 500 board feet make a load.

The bumper or other two-wheeled vehicle is backed under the load so as to engage it just ahead of prop. The load is chained to the bunk and, with the driver standing on the front end to minimize drag, the bumper is started, causing the prop to fall forward. The back of the load drags on the ground. One man driving a single horse can usually move production from mill to pile where the yard is within a quarter mile of the mill.

Rolls.—For mills built off the ground, a simple yet effective method to handle loads up to 1 M board feet utilizes an inclined platform and rollers (fig. 13). The platform's incline from mill to truck is 1½ inches in 10 feet, with the rear about 2 inches above the truck bed. Three wood rollers, each 6 inches in diameter and 7 feet long, are blocked on the skids 5 feet apart. If separations are required, the platform is extended to carry several loads at a time. To transfer the load to the truck, the vehicle is placed opposite the load so that the longest boards will clear the platform when the lumber has been shifted to the truck. A 4- by 3-inch by 7-foot timber is placed on the truck bed about a foot from its rear, with the 8-inch face on the truck bed. A 6-inch roller is placed just ahead on the truck bed, the blocks are taken from under the roller supporting the load, and usually gravity moves the load on the truck. As it engages the roller on the truck, and before the rear of the load drops off the platform, the 4- by 8-inch timber is turned with the 4-inch face against the truck bed to minimize the shock of the drop.

Loading scaffolds.—Variations of devices to support loads clear of the ground, so that a vehicle can be backed under and the load picked up as a unit (figs. 14 and 15) are suited to mills built off the ground.

The type shown in figure 14 is used for loads of about 1 M board feet moved by a truck or wagon relatively short distances to the yard. No grouping is usually made at the mill, other than some sorting of like items within the load. Usually two men transport and pile the production

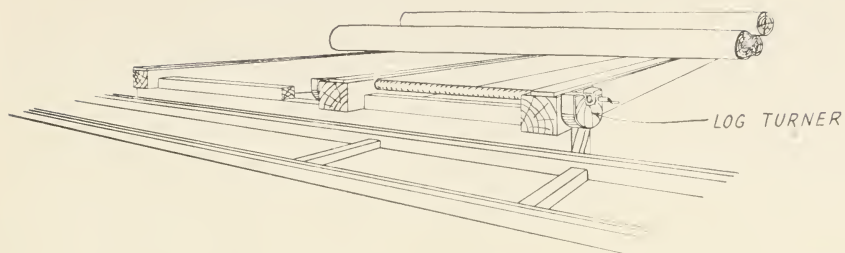
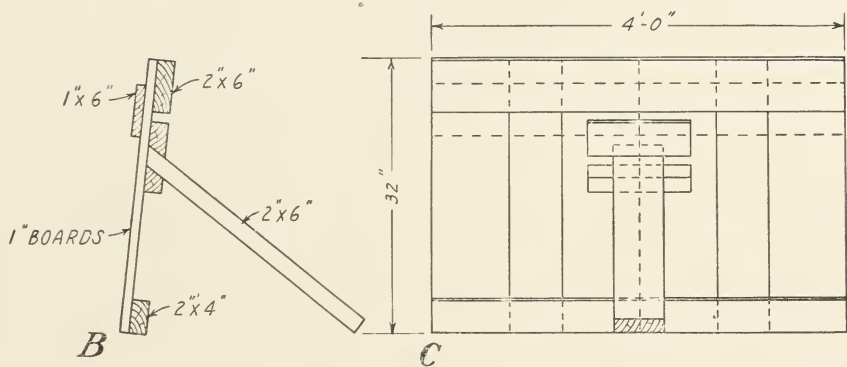
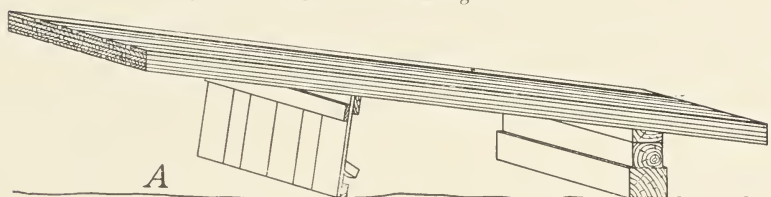


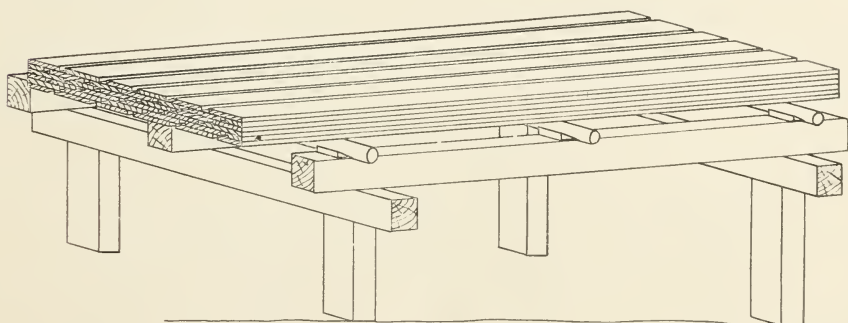
FIGURE 11.—Home-made deck log turner.

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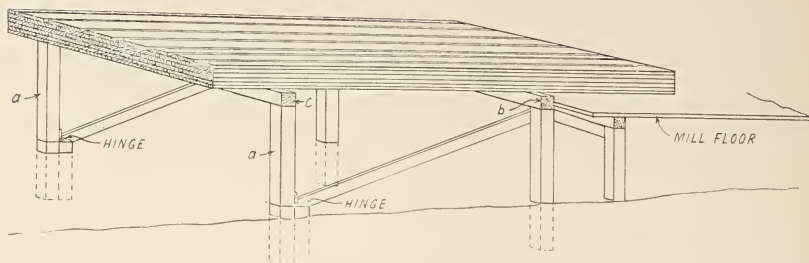
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FIGURE 12.—Lumber prop, suitable for ground mills, for grouping lumber by species, width, length, or grade. *A*, Prop in place, with lumber piled; *B*, side view of prop; *C*, end view of prop.



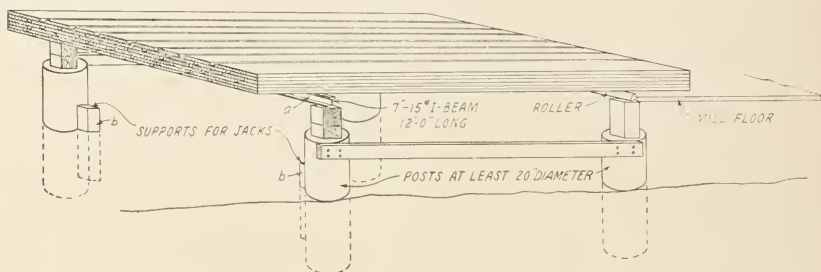
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FIGURE 13.—Inclined platform and rollers for handling loads up to 1 M board feet in mills built off the ground.



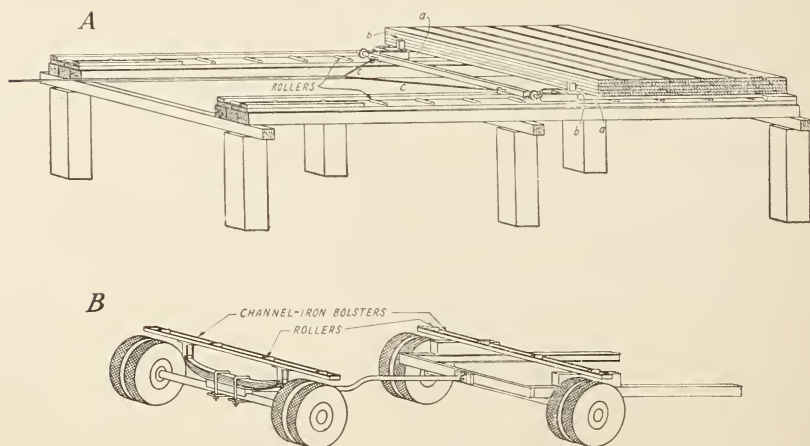
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FIGURE 14.—Loading scaffold for loads of about 1 M board feet, to be moved relatively short distances by truck or wagon. Supports (a) are hinged, to fall back as truck bed or rear bunk engages the load just ahead of supports (b).



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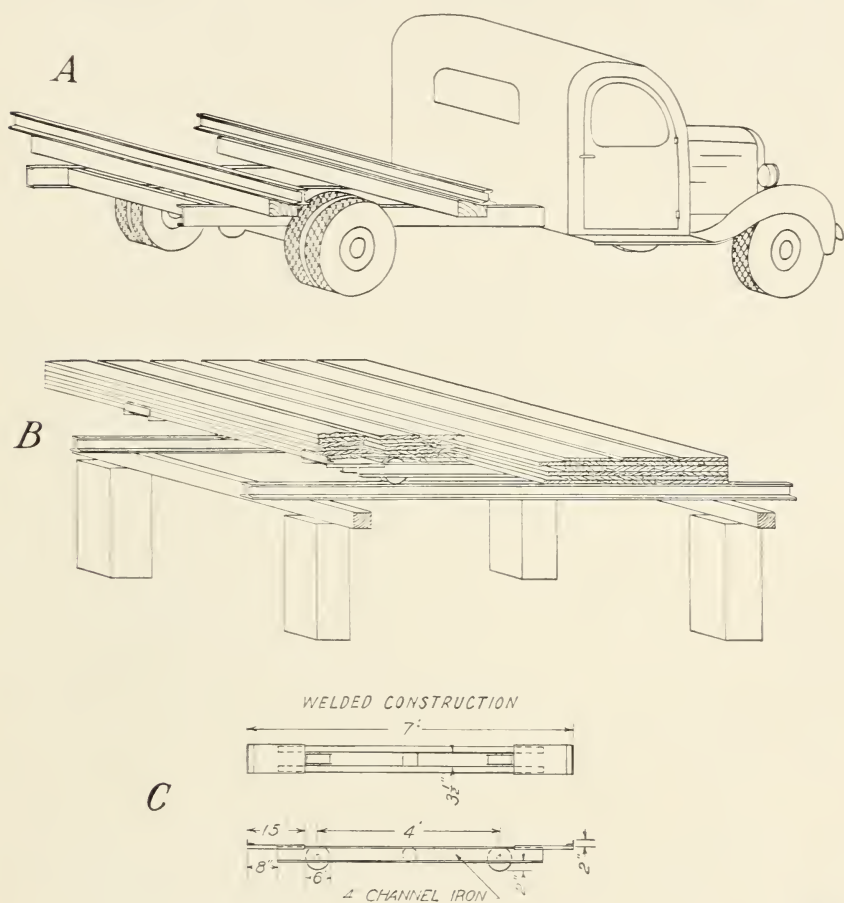
FIGURE 15.—Loading scaffold for truck-trailer loads of 4 M board feet and relatively long hauls. A jack on support (b) raises support (a) and permits removal of blocks as trailer engages load.



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FIGURE 16.—A, Sliding skids, suitable for loads of about 4 M board feet; B, truck trailer with bunks fitted with rollers set in iron bolsters, to make loading and unloading easier.

directly from the vehicle. Supports (a) are hinged. The ground line of the roadbed is so inclined that, in backing between supports (a), the rear end of the truck bed, or, if bunks are used, the rear bunk, engages the load of lumber just ahead of support (b). As the truck continues to back, the load is lifted clear of support (b), and supports (a) fall back, pivoting on the hinges. If a truck bed is used, cross members must be placed so as to support the load more than 6 inches off the bed, to allow (c) to be



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FIGURE 17.—Rail truck (A) and rail skids (B) for handling heavy loads; C, details of skid.

taken from under the load. The distance between supports (a) and (b) will depend upon the truck-bed length or distance between bunks; the extension of lumber beyond the support (c) is regulated to clear the cab. The width of the pile is that readily taken on the truck.

The type shown in figure 15 is used for truck-trailer loads of 4 M board feet and relatively long hauls. The load is supported to just clear the bolsters as the trailer and truck are backed under. The driveway is planked under the load, and enough incline given to engage the trailer bunk with the load at the moment the bunk of the truck is behind the support (a).

The jack is placed on support (*b*) and one end of support (*a*) is lifted, the blocks removed, and the end of the support lowered until it rests on the post. The jack is taken to the other end of support (*a*), and the process repeated until the support can be removed. The load is chained to the vehicle and is then ready to move. The specifications in figure 15 are for bunks 8 feet wide, dual-drive, and dual-wheel trailers.

Sliding skids.—The specifications for sliding skids shown in figure 16, *A* are for truck-trailer loads of 4 M board feet and relatively long hauls. The lumber is piled across skids (*a*) to a load width suited to the bunks of the carrier as indicated by angle-iron guides (*b*). To move the load, a cable from a hand winch anchored bunk high across the truck road is connected to the chains (*c*) and, when operated, pulls the loaded skids over the rolls. Loading and unloading are facilitated if truck and trailer bunks are provided with 4-inch channel-iron bolsters with rollers inset to clear the bolster by about one-half inch (fig. 16, *B*). The truck is placed so that the skids will be ahead of the bolsters rather than opposite, the skids being removed when the load is placed on the bolsters. If a truck with a solid bed is used, the skids are pulled directly on the truck bed and remain under the load. By lengthening the skidway, several loads can be stored against irregularities of truck schedules. The truck driver or helper operates the hand winch. At the delivery point, unloading consists in placing a heavy chain around the load and pulling it laterally on the skids by a power device, or by lifting the load with an overhead crane.

Trucks and rails.—Another method suited to heavy loads requires two firmly fixed sections of railroad rails, each of a length equal to the overall load width (7 feet) across the truck frame (fig. 17, *A*). One rail is about 30 inches back of the rear axle of the truck and the other about 7 feet ahead of this rail. Kiln trucks with a welded extension (fig. 17, *B*) can be placed on rails at the back of the mill, spaced exactly as the rails on the truck. The motor truck is spotted so that its rails are an extension of those from the mill, with not over a 3-inch gap. A jack is used under each end of the rail nearest the cab to bring to and hold the truck rails at the same level as those of the mill. A winch and cable are used to pull the load on the truck. At the unloading point, rails are provided with the proper spacing to permit running the kiln trucks with the lumber off the hauling truck, using jacks and winch as outlined.

SMALL MILL SEASONING

Yard Drying.

Application of the principles outlined hereafter can do a lot to keep the small mill rolling. The present heavy demand for 5/4 and 6/4 hardwood stock is a real challenge to mill operators to so handle the lumber in their yards that it will not be excessively degraded either by checking or by staining and decay. In connection with the recommendations that follow, special attention should be given to sun and wind shields on the more exposed sides and top, especially of oak piled during the hot dry months. Unfilled piles need protection as much as or more than finished piles. Rough board sheathing, so used, will return good dividends. Attention to better ventilation through the lower portion of the piles of some woods that will be yarded during wet seasons is equally important.

Yard lumber can be so stacked as to insure more circulation or less, according to the needs of the species in the pile to minimize degrade. All lumber either gives off moisture to the surrounding air or takes it up until

the moisture in the lumber comes to a balance with that in the air. The rate at which an exposed surface in a yard piece gives off moisture depends upon such climatic factors as dryness, temperature, and wind, which change with both the locality and the season. Although these factors cannot in themselves be modified for drying purposes, proper piling will largely produce the result desired.

The movement of air in a yard pile is of two types. Horizontal circulation, caused primarily by local wind currents, can be regulated to some degree by variation in yard lay-out, foundation construction, piling methods, and arrangement and spacing of piles. Vertical circulation, at least as important as horizontal, is caused by the increased density of the air within the pile as evaporation cools it. This causes a downward flow, which can be regulated to some extent by changing the spacing of the vertical air passages within the pile and by altering the pile foundations.

The seasoning defects that cause degrade divide into three groups: (1) Sap stain and decay; (2) check, honeycomb, and loosened knots; and (3) warp, which includes bow, cup, crock, and twist. The three kinds of seasoning degrade caused by these groups may be minimized by (1) speeding up the drying process by (2) retarding it, and (3) by holding the stock firmly in proper alignment, whatever the rate of drying may be. Among the species especially susceptible to blue-stain degrade are southern yellow pine, eastern and western white pine, ponderosa and sugar pine, basswood, sap gum, and maple. Among the species especially susceptible to check are oak, hickory, sycamore, beech, and hard maple.

The degree to which it is practical to improve air drying practice varies from mill to mill. In general the larger mills can go further toward separating stock by species grade, thickness, length, and width, and permanent mills can do more in drainage, grading, and foundation improvement.²

Flat piling.

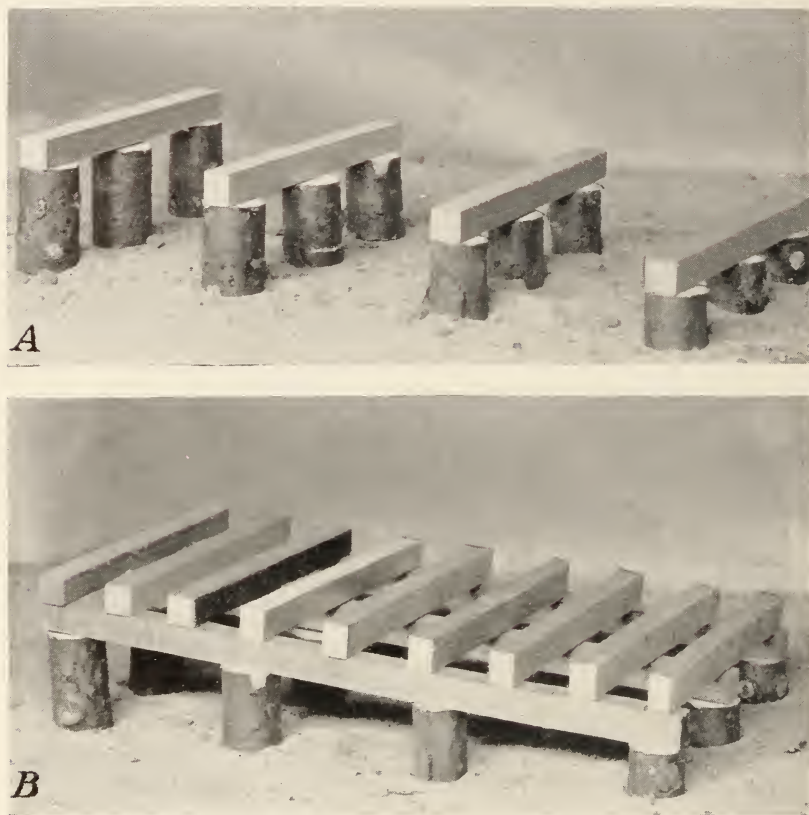
Piling stock flatwise for drying is almost universal. With this method the drying rate is relatively slow and the weight of the pile tends to keep the stock from warping. It is, therefore, suited to species which are apt to check, honeycomb, or warp, and less suited to species which are likely to suffer sap-stain degrade. The following suggestions apply to flat piling.

Choose a well-drained site; for species that withstand rapid drying it should be fully exposed to the wind. Free it from brush and weeds. The foundations must be firm, and must raise the pile above the ground to assist circulation under it. Piers are highly preferable to other types of support, such as stringers laid on the surface of the ground. At permanent yards a practical construction is piers of concrete or creosoted timber supporting substantial stringers, across which beams for sticker support are nailed. At portable operations foundations of standard stock to be marketed when the pile is torn down can be made as follows: Cross-cut a reasonably sound 15-inch log of low value into bolts to provide piers that elevate the first course of lumber at least 18 inches from the ground and give it a slope of 1 inch to the foot from front to rear. Scrape to firm soil at 12 points and bed the piers carefully (fig. 18, A).

Give the front of the pile a pitch toward the ally of 1 inch to the foot of height and align each tier of stickers parallel to this front. Make the front of the pile smooth, especially avoiding projecting ends that would lead rain or drip into the pile.

² More extensive discussion of air drying and additional recommendations for practice are given in U. S. Department of Agriculture Tech. Bul. 174, "Air Seasoning of Wood," by J. S. Mathewson, which may be obtained from the Superintendent of Documents, Washington, D. C., for 35 cents a copy.

Some separation of stock by thickness and species is usually practicable. For 8/4-inch stock, lay one 4- by 6-inch beam on edge across the end piers at each end; and similarly lay two across each of the two intermediate series of piers, or use one 6- by 8-inch laid flat for each intermediate. In laying courses, intersperse the longer stock uniformly across the pile, always placing a long piece on the outside and keeping each tier of uniform length. Pile 2- by 4-inch stock with the 4-inch face vertical, and space adjacent pieces in the course 1 inch apart. Sticker with 2- by 4-inch stock, the



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FIGURE 18.—Bases used in flat piling: *A*, temporary base; *B*, permanent base.

4-inch face horizontal, and place one sticker over each beam, making four to the course.

For stock less than 8/4 inches in thickness proceed as follows: For hardwoods lay a 6- by 8-inch stringer of tie stock along each row of four piers, on edge and aligned to support the lumber evenly. Then lay cross beams at each end and at 2-foot intervals between (fig. 18, *B*). For softwoods omit the stringers and lay cross beams on each row of three piers, using either single 6- by 8-inch or single 4- by 6-inch pieces at each end and two such pieces for each central row, as in figure 18, *A*.

Random lengths and widths of stock less than 8/4 inches thick can be box-piled. The aim in box piling is to build up tiers, separated by flues,

in such a manner that the various lengths are supported firmly and the flues are unobstructed from top to bottom. A given tier is made up, as far as possible, of boards of similar length; the longest boards go into the outside tiers with additional tiers of long boards uniformly distributed across the pile. Tier width approximates 12 inches, so that each layer in a tier may be formed of two 6-inch boards, or an 8- and a 4-inch, or a single 10- or 12-inch board. Flues between tiers average 4 inches in width. Where losses from stain are paramount increase this width up to 6 inches, and where shrinkage defects dominate reduce it. Carrying tiers straight up assures the unobstructed vertical flue that is necessary for good drying.

The choice of stickers for boards less than 8/4 inches thick is among narrow stock, edgings, and strips sawed and dried for the purpose. Self-stickering is convenient but where it would lead to serious losses, through stain and check, narrower and drier stickers are less costly. At permanent yards, stickers about 1 by 2 inches for softwood and 1 by 1½ inches for hardwood are sawed, preferably from heartwood, and dried. At portable mills, edgings that have air-dried for about a week provide relatively cheap, partially dry stickers.

Roof all piles by placing cross supports (two 2- by 4-inch by 8 feet laid flatwise, one on top of the other), at front, center, and rear to raise the roof off the lumber and then putting a double layer of low-value stock on these supports so as to project 2½ feet beyond the rear of the pile; stagger all openings in the layers. At the front allow 1 foot overhang and if necessary have the front cover partly overlap the rear cover. In windy regions the roofs should be wired down. The spacing between piles should be 4 feet and, where edging stickers are used, alternate piles should be set back a foot to avoid the interlocking of random-length stickers. Rear alleys should be at least 8 and main alleys 16 feet wide.

Since the drying rate and the consequent degrade from blue stain, decay, or shrinkage defects are likely to vary with the location of the pile, the species of wood, and the season, some refinements in piling practice may be profitably considered, as summarized in table 3.

TABLE 3.—*Methods of piling yard lumber for seasoning to reduce occurrence of degrade from checking, warping, and blue stain and decay*

To reduce checking—	To reduce warping—	To reduce blue stain and decay—	
		Throughout the pile	In lower part of pile only
Lower the foundations; decrease the spacing between boards and between piles. Use thinner, narrow stickers. Place the end stickers so that they project beyond the ends of the pile. Use end coatings. Use sun and wind shields.	Use stickers of uniform thickness, properly aligned and supported, and sufficient in number.	Raise the foundations. Increase the spacing between boards and between piles. Provide one central flared chimney or a series of narrow chimneys. Narrow the piles.	Provide short chimneys ½ or ¾ height of pile. Use thicker stickers in lower part of pile only.

End piling.

Because the terms "end piling" and "end racking" are similar they are sometimes confused. Actually they are widely used in the trade to refer to entirely different methods of piling, the results of which are quite unlike.

Lumber piled on end is comparable to a flat pile tipped on end. End piling is economical of labor, since one man can put up and take down; it gives relatively fast although not uniform drying. Because of the speed of drying, however, thick stock, 8/4-inch and upward, of most species would be liable to excessive checking and so should be flat-piled. End piles can be built to take random widths by piling like widths in the same row, but like lengths should be grouped.

In its simplest form, end piling requires a floor, a central rack, and strips supporting a single series of stickers. The floor is cull stock, and for



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FIGURE 19.—End piling and end racking are two distinct methods of piling, different in appearance and in results. *A*, End pile, in background; *B*, lumber end-racked.

portable mills can be improvised from edgings supported at 2-foot intervals by slabs grounded so as to level the floor roughly across although not necessarily along the pile. Lay the floor several days before stacking, to give it time to dry. The 2- by 12-inch by 12-foot cap plank of the rack is supported 8 feet above ground by 4- by 6-inch upright posts, which are given stability by 4- by 6-inch braces (fig. 19, *A*). The sticker supports shown in figure 19, *A* are 1- by 4-inch strips continued from the central rack and nailed lightly to the pile edges. When a single sticker to the course suffices, the height of sticker is 8 feet. When the warping hazard requires more, the spacing is about 4 feet.

To start, put a sticker (either an edging or narrow stock) across the sticker supports, and lay the first course, tilting boards against the support. Nailed strips for sticker supports can be dispensed with by providing the piler with a rakelike home-made sticker holder consisting of a handle of a length equal to the height of the sticker placement and cross arm about 3 feet long. A sticker is laid across the cross arm and boosted in place, and the handle end is rested on the ground. The piler then places the two outside boards of the next course against the sticker, removes the support, and finishes the course. The space between adjacent boards approximates 8 inches. The exact width of pile, which approximates 10 feet, depends upon the frequency of occurrence of the various widths.

Succeeding courses are a repetition of the first; care should be exercised to align tiers to make the 8-inch spacing continuous the full length of the pile and tilt boards parallel to the corresponding ones in the preceding course. Load the rack evenly up to 8 M board feet on each face before attempting to load one face more heavily than the other. Such piles are from 75 to 100 feet in total length.

End racking.

In the quite distinct procedure of end racking, two rows of end-piled lumber are crossed like an X, or preferably like an inverted V (fig. 19, B). The resulting open pile has a drying rate too rapid for most woods if drying is continued to the air-dry condition. This method suits where speedy partial drying is desired; for example, to carry stain-susceptible stock quickly below the stain-favorable condition, or to lighten the load between the mill and the concentration yard. Stock can be brought to a condition of low stain, but high shrinkage-degrade hazard in 3 to 15 days, depending upon the weather, and can then be flat-piled or sent to the concentration yard.

The essential features of such a rack are a ridge pole, base supports, and middle supports. Where valuable stock is involved, two refinements are desirable: (1) To elevate the base supports a foot above the ground; and (2) to make separate racks for each length, so that the lumber crosses at the extreme ends.

Crib piling.

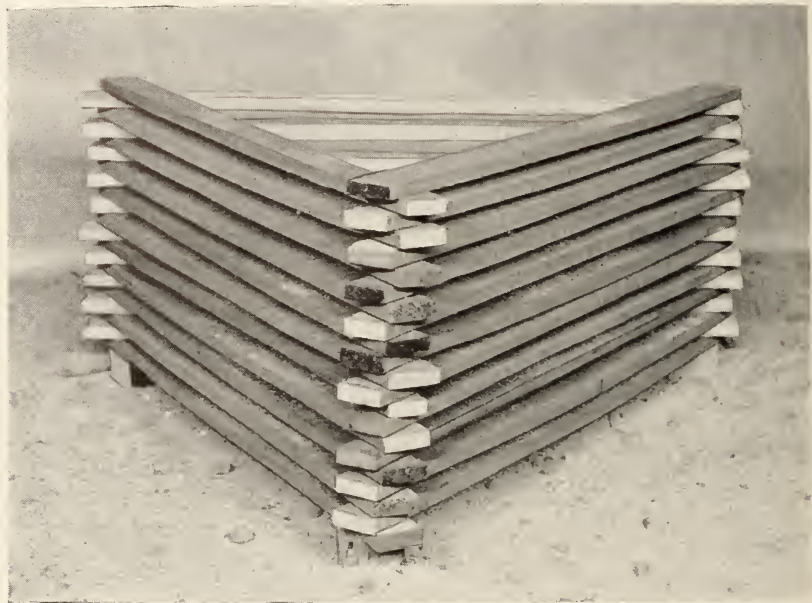
Crib piling is another method for speedy partial drying that is practiced by small mills cutting pine. It eliminates foundation, stickers, and pile covers, but requires excessive yard space. It is likely to give high degrade from stain at the ends where the planks are crossed and from warp in the long, unsupported intervals between ends. Separate piles are made for each length by cribbing three tiers in the form of a triangle (fig. 20). The first plank rests on supports at each end, one end of the second plank crosses the first above a support and the other end rests upon the third support of the triangle. The third plank closes the triangle. In succeeding courses this crib work is carried to a height convenient for one-man stacking. The planks cross directly above the supports.

Dipping Tanks for Stain Prevention.

The gravity dip tank shown in figure 21 is placed alongside the rolls and immediately beyond the swing trim-saw. The trim-saw operator tips to the inclined skids the boards to be dipped. The slope and length adjustment of the 1½-inch pipe skids are such that the weight of the boards being tipped off the rolls pushes the other ones through the liquid to the discharging side. Normally, excess liquid drains off the board and into

the tank as the board emerges and before it drops to the skids at the discharging side. This equipment permits dipping 2 M board feet per hour.

The conveyor-chain dip tank outlined in figure 22 is usually so placed that the lumber, after trimming, is conveyed through the tank and thence to the sorter chain. Power for driving the conveyor chains, applied to the sprockets on the shaft at the entering side of the tank (fig. 22, *B*), together with the rider wheels insures submergence of the chain and conveyed material. Strap iron 3 inches wide fastened to the tank under the chains prevents excessive wear, and the angle-iron section serves to guide the chain. The chain has no lugs. The tank is floored with a double layer of 1 by 6 tongue-and-groove material staggered as shown (fig. 22, *B*).



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FIGURE 20.—Crib piling requires no foundation, stickers, or pile covers, but takes up a large area for the volume piled.

The rider wheels (iron pulleys) hinge on a frame supported above the tank (fig. 22, *C*). The least waste in liquid results when the speed of the chain is the minimum required to move production; 30 feet per minute is suggested for mills with a capacity up to 2 M board feet per hour. For higher speeds, the length of the 10-foot section should be increased. Approximately 130 gallons of liquid will suffice to keep the dip to the level shown, and the tank should have outlets permitting drainage and cleaning. A mixing tank (fig. 22, *A*) of at least 50 gallons capacity and a shelter over all complete the equipment.

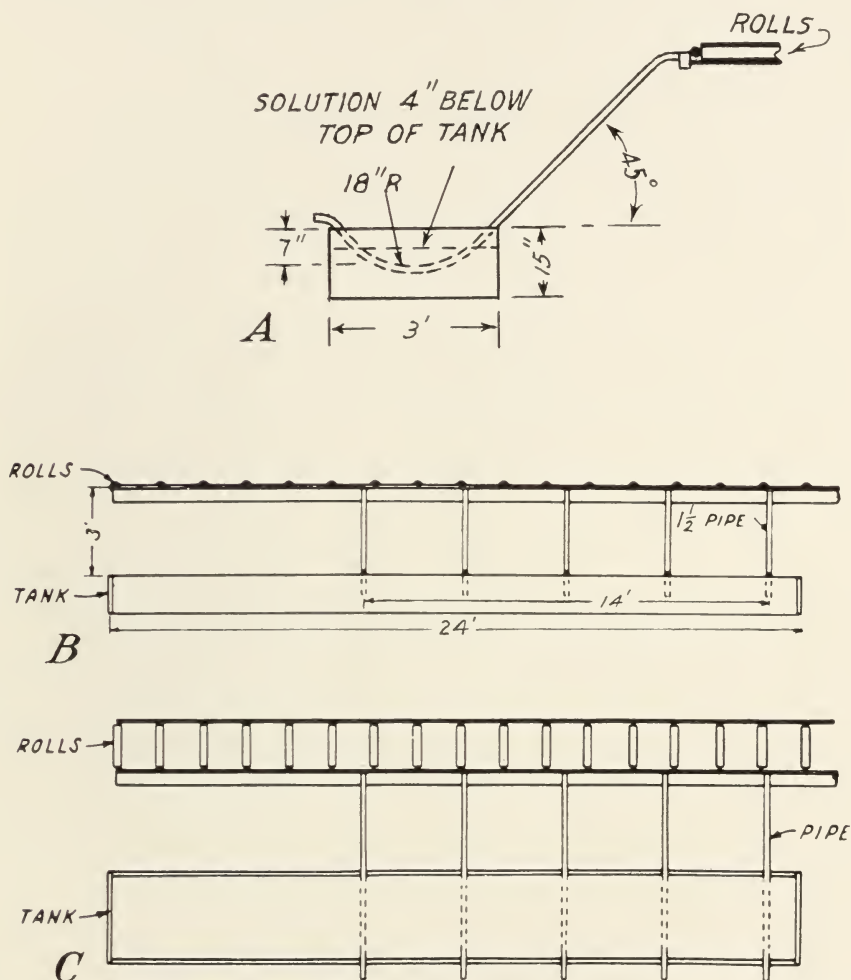
If chemicals used are irritating to eyes or skin, workers should wear goggles and oiled leather gloves.

End Coatings.

Since wood dries faster from the end grain than from the side grain, some kinds of wood, especially in thick size, may check and split during

air seasoning. For this reason it is often advisable to use a moisture-resistant end coating for air seasoning or kiln drying.

Coatings ordinarily used are of two classes. Those in the first class are liquid at ordinary air temperatures and can be applied cold. Those in the second class are solid at ordinary temperatures and must be heated before



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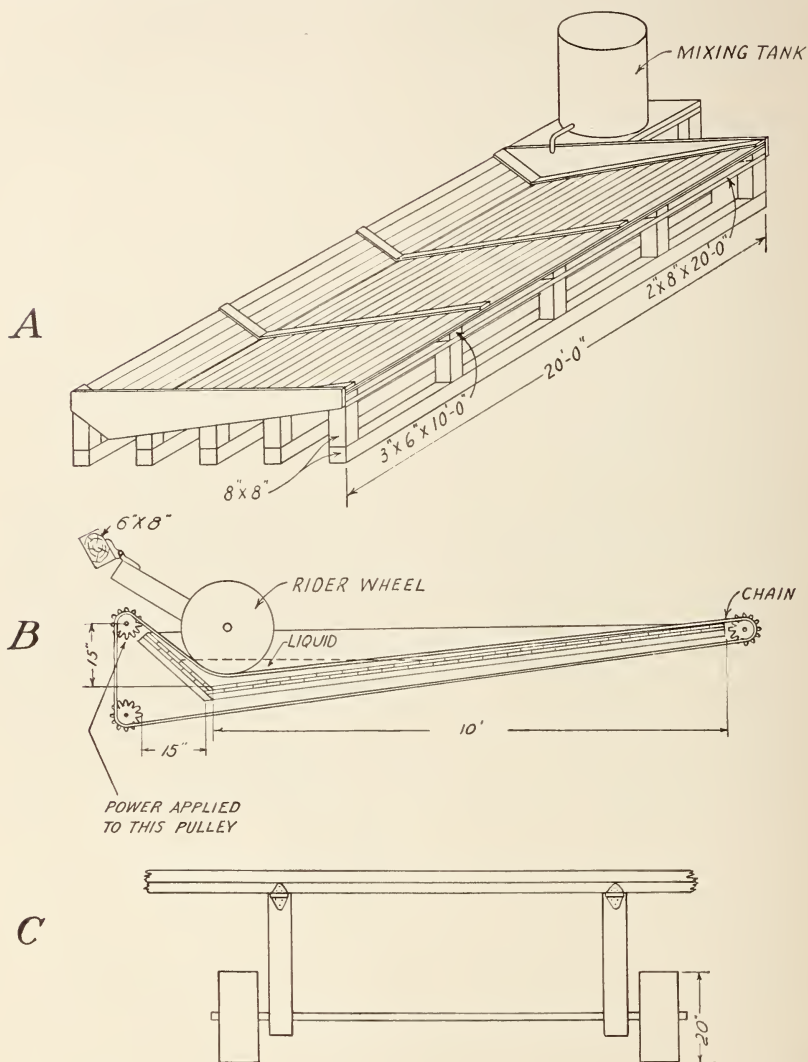
FIGURE 21.—Gravity dip tank for stain-prevention dipping: A, End view; B, side view; C, top view.

being applied. The hot or cold coatings are effective for drying temperatures up to 140° F., but for temperatures between 140° and 170° hot coatings only should be used.

The two best cold coatings developed are hardened gloss oil thickened with barytes and magnesium silicate (very cheap), and high-grade spar varnish and barytes (expensive).

The gloss oil should be of a thick grade, made up (by the paint manufacturer) by weight of about 8 parts of quick lime, 100 parts rosin, and

57.5 parts mineral spirits. To 100 parts of the gloss oil add 25 parts barytes and 25 parts of magnesium silicate. One or two parts of lamp-black can be added if a black coating is desired. This coating can be made



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FIGURE 22.—Conveyor-chain dip tank for stain-prevention dipping: A, Top view; B, detail of conveyor chain; C, detail of rider wheel.

by any paint manufacturer, or it can be mixed by the user as needed, in case the proper grade of gloss oil is obtained. Some gloss oils have little moisture resistance, and it is necessary, therefore, that the coating be made up according to the above formula.

Paraffin, if obtainable, is a satisfactory end coating for use on material which is to be air-seasoned, but its melting point is too low for use on stock to be kiln-dried.

The most effective method of applying hot coatings is to dip the ends of the stock about one-half inch into the coatings. For this reason it is difficult to apply these coatings to large-size material. Hot coatings are effective in the following order:

Coal-tar pitch at 213° F.	(cheap)
Coal-tar pitch at 254° F.	(cheap)
Rosin and lampblack (100 parts rosin to 7 parts lampblack) . . .	(moderate cost)

Boilerless Dry Kilns.

Kilns with steam coils, fans, humidity, and temperature controls are obviously more dependable, but several of the softwoods and a few of the less refractory hardwoods in thicknesses of 1 inch and perhaps greater can be satisfactorily dried at portable mills by means of an inexpensive home-made kiln.

Construction.

Firebox.—A section of discarded smokestack laid in a shallow trench comprises the firebox. One end of the stack should be walled with brick, rock, or a metal plate. An outlet large enough to take a large-sized stove-pipe should be made on the upper side of the stack near the walled end.

Pile foundations.—Pile foundations are built to hold one stack of lumber on each side of the firebox allowing a 1-foot space between each pile foundation and the firebox. Each foundation has four supports. Each support consists of a sill sunk level with the ground line, two uprights, and a cap. The caps should be aligned to support the lumber evenly. Solid supports built by piling up timbers should not be used.

Building.—A building, the back and side walls of which consist of three sections held in place with interlocking studs, is placed about the firebox lumber piles (fig. 23). The back and sides have sheathing on both sides of the studs, so that the walls can be filled with sawdust. The front consists of panels made of a double layer of boards with tar paper between. The roof is also constructed of panels made of a single layer of boards supported by two rafters, attached at the front to the same sized studs, and at the back to the interlocking studs of the top section of the back wall. The roof panels are laid, not nailed, across the two rafters, so that their ends overlap the inside layer of wall sheathing but do not reach the outside layer. Strips of tar paper are laid, not nailed, over the roof panels and about 2 inches of sawdust are placed on top of the paper; plenty of sawdust should be placed at the junction of the roof and side walls. This roof is not put on the building until the lumber has been piled within, and it is removed before taking out the charge. In removing it, the sawdust is swept to the rear-most panel, the tar paper rolled back to it, and the exposed panels piled on top. The outside layer of the side wall and back walls is carried 6 inches above the inside one; at the front, it is more convenient to carry the inside layer above the outside one, to keep the sawdust from blowing off the roof.

The front of the building has a built-in panel and two detachable panels which serve as doors. The built-in panel is nailed from center to center of two full-length studs, and carried down to within 4 feet of the ground. The detachable panels are set in place on each side of the built-in panel. The firebox projects about 2 feet outside the built-in panel. A smoke pipe is connected to the back end of the firebox after the building is erected.

An angled elbow brings the smoke pipe out the front built-in panel about 2 feet below the roof and directly over the firebox. A length of iron pipe, extending through the built-in panel and resting against the back wall directly above and parallel to the stove pipe, serves as a support to which the stove pipe is wired.

Fire safeguards.—This kiln is capable of generating high temperatures and, unless safeguards are taken, will catch fire. The ends and faces of the foundations abutting the firebox should be insulated with tin shields (fig. 23, *B*). In addition, corrugated galvanized-iron sheathing should be put along the lower part of each lumber pile on the sides exposed to the firebox. By nailing the sheathing to stickers that project about 4 inches from the edges of the piles and foundations, an effective baffle is obtained. A 6-inch space between the ends of each baffle and the front and back walls should be left for air circulation. An 8-foot length of corrugated galvanized iron is placed at the back of the firebox in order to protect the rear wall. A metallic collar between the stovepipe and front wall safeguards the wall. The outside of the firebox where it passes through the front wall should be bricked (fig. 23, *A, D*). A piece of tin should be curved about the top of the firebox and placed across the two brick walls, in order to throw the heat into the kiln and away from the front wall. A space of approximately 4 inches is left between the firebox and this tin. Another tin is nailed over the opening above the firebox, where the front built-in panel is not carried down. This junction of firebox and front wall must not be airtight, because some ventilation is needed here as a further safeguard against fire.

Operation.

In loading the kiln, six green 2- by 4-inch by 16-foot pieces are placed across the four foundation supports to provide a base for stickers, care being taken to space the pieces so that tiers of boards rather than flues are directly over them. Six stickers to the course are then placed at each end and at regular intervals across these pieces.

For successful operation the lumber should be box piled; that is, 16-foot boards should be placed on the outside tiers, and shorter lengths on the inside tiers, placing the ends of the shorter lengths flush with the front and the back of the pile alternately. In the next course, insofar as possible, the short boards should be placed flush with that end of the pile not reached by the short boards in the same tier of the course below. The tiers should be carried one directly above another, and a spacing not less than 4 inches to each 12 inches of boards should be allowed between tiers. This method of piling results in vertical flues that allow a free downward flow of air from the top to the bottom of the pile. The stickers should be aligned directly over the corresponding stickers in the course below. The pile should be carried straight up to within a foot of the roof, but should allow a space of 6 inches or more between the side walls and piles. A duplicate pile is put up on the other side of the firebox.

Approximately 5,000 heartwood stickers should be sawed out, since they may be used repeatedly. In tearing down a pile the stickers for the upper half of the pile are placed across the 2 roof rafters.

When the kiln is loaded and roofed, and the front closed, a fire is started and kept continuously day and night until the lumber is dry. A sheet-iron plate over the front end of the firebox serves as a door and controls the draft to some degree; a damper in the smoke pipe outside the kiln offers more

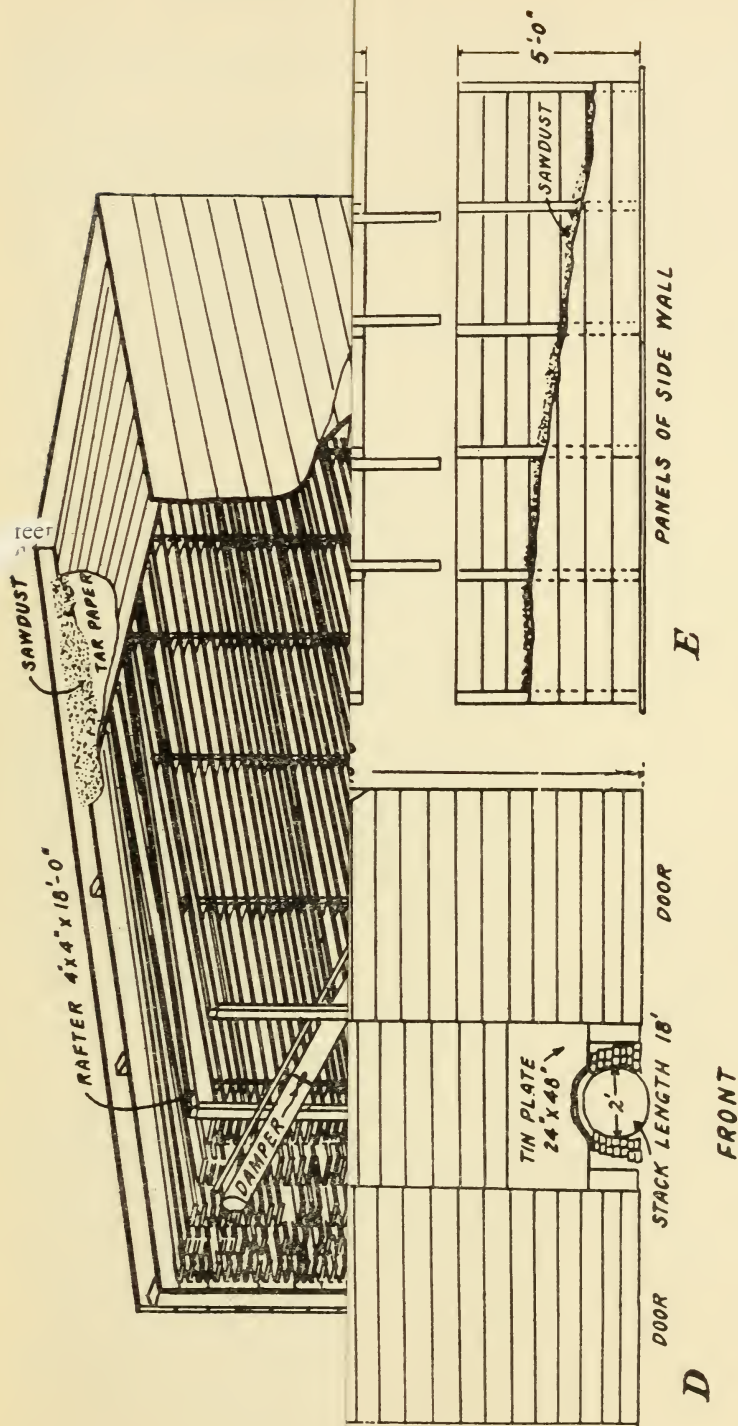


FIGURE 23.—Detail of building construction for a boilerless dry kiln: A, Detail of interior and roof; B, sill; C, upper panel of rear wall; D, front elevation; E, panels of side wall.

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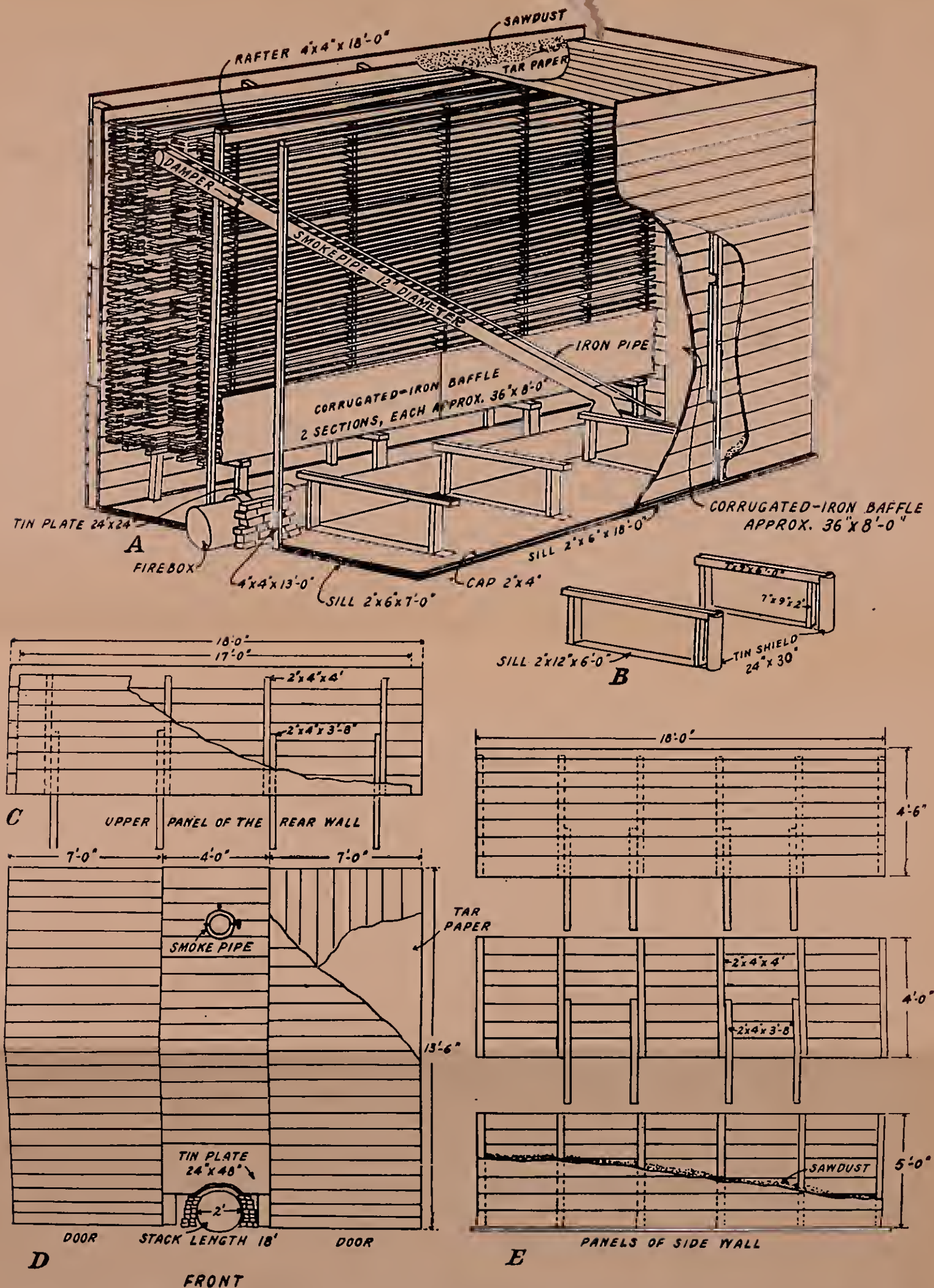
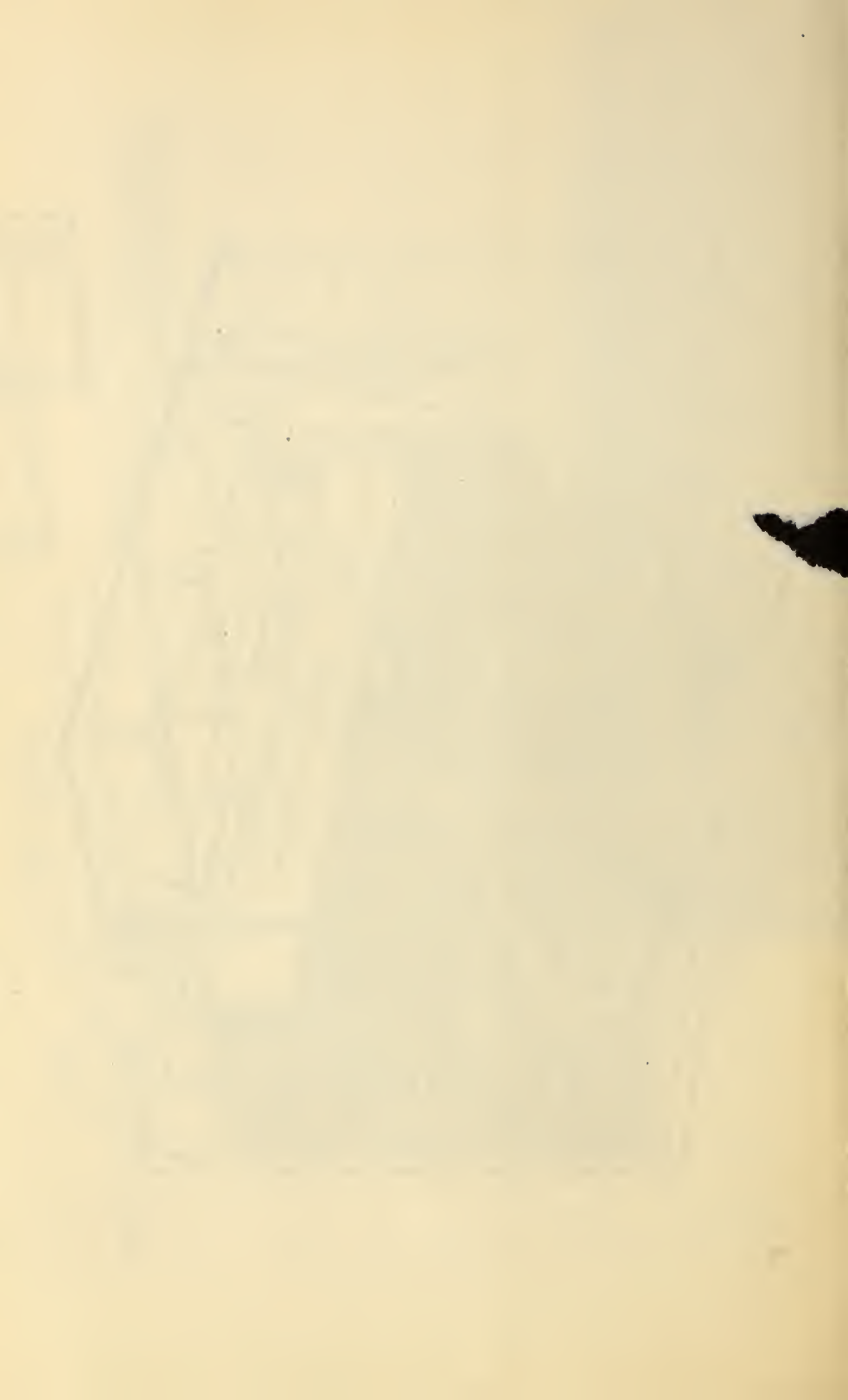


FIGURE 23.—Detail of building construction for a boilerless dry kiln: A, Detail of interior and roof; B, sill; C, upper panel of rear wall; D, front elevation; E, panels of side wall.

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complete control. As the charge dries, the sawdust joint at roof and walls is apt to open, making it necessary to place more sawdust in the settled sections.

The progress of drying can be roughly determined by holding the hand at the crack at the juncture of the side wall and front where the hot air is pouring out. So long as the fingers feel moist after a minute's exposure, the lumber is losing moisture rapidly. As the charge approaches a dry condition, the air moisture drops, the temperature increases, and it is thereafter advisable to carry only a moderately hot fire.

The small-mill operator ordinarily dries his entire cut, and to do so would need a battery of these kilns. The capacity of the kiln described here is about 7 M board feet. A mill cutting 7 M board feet per day and using a 4-day drying schedule would require five or six such kilns. The structure shown in figure 23 necessitates that each charge be piled in and out. Where production warrants, these kilns can be modified to handle trucks.

Bill of material.

Heater.—A $\frac{1}{4}$ -inch sheet-iron firebox, 2 feet in diameter, 18 feet long; 22 feet of 12-inch stovepipe, an angled elbow (45° adjustable), 1 damper and flue collar; a sheet-iron plate 24 by 30 inches.

Fire safeguards.—Fifty brick; a piece of tin 24 by 48 inches, one 24 by 24 inches, and 8 pieces 24 by 30 inches. Five sheets of corrugated iron approximating 36 inches by 6 feet each.

Foundations.—Eight 2- by 12-inch by 6-foot sills. Sixteen 7- by 9- by 24-inch uprights. Eight 7- by 9-inch by 6-foot caps.

Walls.—Three 2- by 6-inch by 18-foot sills. Two 2- by 6-inch by 7-foot sills. Three 2- by 4-inch by 18-foot sills, and two 2- by 4-inch by 7-foot sills. Sixteen 2- by 4-inch by 13-foot studs (to be sawed into 3 parts after erection). Twenty-four 2- by 4-inch by 3-foot-8-inch cleats. Two 4- by 4-inch by 13-foot studs. Two 4- by 4-inch by 18-foot rafters. Inch sheathing all widths as follows: 1,430 board feet in 18-foot lengths for 2 sides and back walls, 210 board feet in $13\frac{1}{2}$ -foot lengths vertically in doors, 40 board feet in 4-foot lengths horizontally in built-in front panel, 40 board feet in 9 $\frac{1}{2}$ -foot lengths vertically in built-in front panel, 216 board feet in $7\frac{1}{2}$ -foot lengths horizontally in doors, 325 board feet in $17\frac{1}{2}$ -foot roofing.

Miscellaneous.—625 square feet tar paper. Sawdust. 5,000 stickers $1\frac{1}{2}$ by 1 inch by $6\frac{1}{2}$ feet. Wire. Nails.

SMALL SAWMILL ACCOUNTING

Operators of small sawmills ignore completely or in part the inevitable expenditures for depreciation, maintenance, and repair of equipment, taxes, and interest on capital tied up in their businesses. These costs ran from 9 to 22 percent of the total cost in five different types of small mill operations studied by the Forest Products Laboratory. Failure to take these costs into consideration is one of the serious contributing factors to the high business mortality among operators of small mills.

The following accounting system, in which the foregoing costs are given proper consideration, is suggested as a pattern to meet the requirements of small sawmills. The records called for under this system show the essential details of expenditures, receipts, and inventories, reflect the status of individual accounts, furnish facts for use in connection with the Fair Labor Standards Act of 1938, and permit segregations of costs and returns for income-tax purposes.

The pattern suggested is reduced to the simplest form necessary, and requires but a single listing of all expenditures and receipts. In the forms presented, the labor account is segregated from other expenditures in order to have this information available to meet the Federal wage-hour requirements. Individual operations may benefit from further separating special classes of items in the purchases ledger, carrying as separate accounts such items as timber and its products, interest, taxes, insurance, and rent.

Records of purchases and expenditures and of sales and receipts are entered currently and balanced monthly. A year-end balance is made between assets and liabilities, and the net profit or loss from the current year's operation computed.

Balance Sheet.

A balance sheet is ordinarily made yearly in small enterprises. The procedure is to balance assets (cash; accounts receivable; timber, logs, and lumber in stock, plant, and supplies) against liabilities (debts owed by the business). These items are made up as follows:

1. *Cash*.—All cash, checks, and negotiable notes on hand at the end of the year.

2. *Accounts receivable*.—All collectible unpaid balances owed by customers as shown on the December 31 record of sales, receipts, and accounts receivable. Uncollectible accounts are written off and listed as bad debts for income-tax purposes.

3. *Timber, logs, lumber in stock*.—A year-end inventory is made of these and a value is allotted them. This value should be either the cost or the market value, whichever is lower. Yard inventories are simplified if the date, item, footage, and species are marked on the pile when it is completed, for example, "1/12/40—4/4 No. 1—3,650—ash." Logs are inventoried by checking the footage and converting to cost or value, after discounting expected transportation costs for logs in the woods or in transit. Timber is inventoried by estimating the footage and converting to cost or value.

4. *Plant and supplies*.—The plant consists of buildings and equipment required for the operation. Its value should be based on material purchase price plus installation cost apportioned over the remaining useful life to the operation. Buildings in permanent operations are commonly discounted at the rate of 5 percent yearly (original cost divided by 20); for temporary operations, discount yearly the original cost divided by expected life of operation at that site. Other equipment is discounted yearly by a sum equal to the purchase cost divided by the expected life. If the item outlasts the estimated life, no value is given; if the useful life falls short of the estimated life, the undiscounted balance is subtracted from the value of all equipment. The total sum of these yearly discounts on equipment and plant is the depreciation account required for income-tax purposes (see below).

Supplies as distinguished from equipment are short-life items (less than a year), such as stock feed, gas, oil, small tools, etc. For the balance sheet account those carried into the new year are given a value as of December 31.

5. *Liabilities*.—All unpaid bills as of December 31 as shown in the December record of purchases and payments.

The accounts carried to this point serve as records of individual transactions between the business, its creditors, and debtors, and provide in the balance sheet a yearly statement contrasting assets with liabilities.

Federal Income Tax Computation.

A further analysis is necessary to determine the net profit or loss over the year. Items of and computing method for profit and loss for Federal income-tax purposes consist of the following:

1. *Total receipts.*—Accounts paid and payable for sales of current year as shown in the total value of all sales over the year taken from monthly totals after deducting total claims and discounts. Accounts payable carried from the previous year (shown on the January record of sales-receipts—accounts receivable for current year) are not included. Accounts payable at the end of the current year for items sold within the year are included.

2. *Labor.*—All wages paid and payable for work performed within the current year, taken from the pay roll form as total earnings summation. Unpaid wages carried from the previous year are excluded. Unpaid wages at the end of the current year are included.

3. *Materials and supplies.*—Purchases normally used up in a year or less. Equipment normally used for more than a year is excluded and accounted for under depreciation (item 15, below). Purchases of timber, logs, and lumber are accounted for under merchandise bought for sale (item 4, below). Materials and supplies thus include feed, veterinary service, shoeing of animals, oil, gas, files, bits for saws, belt lacings, etc. The total cost is taken from the record of purchases and payments.

4. *Merchandise bought for sale.*—All purchases of timber, logs, and timber products made during the year and shown in the record of purchases and payments.

5. *Other costs.*—Exchange charges on checks, abstracting and attorney fees, surveying expenses, etc.

10. *Salaries.*—All wage payments for regular employees not recorded in the labor account as shown in the record of purchases and supplies.

11. *Interest on business indebtedness.*—Interest payments made during the current year on money borrowed for conducting the business. Taken from records of purchases and payments.

12. *Taxes and insurance.*—Federal, State, and local taxes, social benefit assessments, and insurance payments assessed the business during the current year as shown on the Record of Purchases and Payments. Any assessments included in the pay-roll form are not repeated here.

13. *Losses.*—Losses within the current year not reimbursed by insurance to the property or stock from fire, flood, theft, etc. These losses are given a value in line with book values carried in the balance sheet inventory of of assets.

14. *Bad debts.*—Credits which are uncollectible and eliminated from the assets in the balance sheet inventory of assets.

15. *Depreciation.*—The total sum of the yearly discounts on equipment and plant as determined in subdivision 4 of the balance sheet.

16. *Rent, repairs, etc.*—Rents, payments for options, leases, etc., repairs on equipment not recorded under materials and supplies (item 3, above), and shown in the Record of Purchases and Payments.

The method used on income-tax statements to determine the net profit or loss is as follows: To the sum of the costs of items 2, 3, 4, 5, 10, 11, 12, 13, 14, 15, and 16 add the value of the inventory taken at the beginning of the year and then subtract the value of the inventory taken at the end of the year. This represents the total costs of doing business for the year. Subtract from the total receipts (1) in order to determine the total net profit or loss for the year.

Total net profit or loss per M board feet is found by dividing this net profit or loss by the number of thousand board feet sold during the year as given in the totals on the record of sales-receipts-accounts receivable.

To start this accounting make a balance sheet of the business. The assets consist of (1) cash, checks, negotiable paper on hand, (2) accounts receivable, (3) the value of timber, logs, and lumber in stock, (4) the value of plant and supplies. The liabilities are all unpaid bills and obligations.

Allow enough space in the purchases-payment and in the sales-receipts ledgers for entering under an individual account all probable purchases during the month. At the end of the month balance each individual account on both ledgers, and enter unpaid balances as first item of these accounts for the succeeding month. Reserve a sheet for monthly summaries going to make up year-end balance sheet and profit or loss statement, and fill in the totals for the month for the headings suggested on the lower part of the record of purchases and payments form and on the record of sales-receipts-accounts-receivable form.

Simple Record Forms.

The following record forms will serve to chronicle the small-mill transactions and provide the necessary data for the trial balance.

RECORD OF SALES, RECEIPTS, ACCOUNTS RECEIVABLE FOR MONTH OF 19

Date sold	Name and address of party to whom sold	Item	Number of units	Price per unit	Total value of sale	Amount paid	Date	Unpaid balance	Claims and discounts
2/6	A. T. Staples, Columbia, Va.	8/4 #2C R. L.	20,000	\$19.00	\$380.00	\$350.00	.....	{ \$47.50 30.00 }	.....
	Monthly summary .....	.....	150,000	.....	2,500.00	1,500.00	.....	1,200.00	\$30.00

Note.—Allow enough space under each individual account for all probable sales during the month. At the end of the month, balance each account and enter unpaid balance as the first item for the succeeding month. At the end of the month also make a monthly summary of the total quantity sold, total value, amount paid, unpaid balance, claims and discounts. The total value of all sales after deducting for claims and discounts is used in the yearly profit or loss analysis.

RECORD OF PURCHASES AND PAYMENTS FOR MONTH OF 19..

Date bought	Supplies—services—timber						Personal account amount withdrawn from business	Date
	Name and address of party from whom bought	Item	Price	Amount paid	Date paid	Unpaid balance		
6/1	Anderson Filling Sta., Rhea, Vt.	Brought forward	.....	.....	.....	\$16.00	.....	.....
6/1	do.....	100 gallons gasoline.	\$15.00	\$12.00	6/1	3.00	.....	.....

Note.—Carry a separate record for each account, balance at the end of the month, and bring forward the unpaid balance as the first entry for the ensuing month. Year-end balance and profit and loss statements will be simplified if a different colored ink or symbol is used for equipment subject to depreciation accounting and for purchases of timber, logs, and lumber. From above records monthly summaries may be made of sales, earnings, materials and supplies, merchandise bought for sale, other costs, salaries, interest on bonded indebtedness, taxes, rent, repairs, etc.

Expected-life estimates and depreciation may be facilitated by the following averages derived from small-mill operations:

Item	Expected life (years)	Yearly depreciation (percent)
Horses.....	5	20
Mules.....	5	20
Sleds.....	5	20
Log wagons.....	5	20
Felling tools.....	1	100
Trucks (logging).....	4	25
"Cats".....	4	25
Tractors.....	4	25
Shacks and buildings.....	(¹)	-----
Jammers.....	3	33 $\frac{1}{3}$
Mill building.....	(¹)	25
Steam engines.....	20	5
Gas units.....	10	10
Diesels.....	15	7
Edgers.....	10-12	10
Mill machinery.....	10-12	10
Trim saws.....	10-12	10
Rolls.....	10-12	10
Saws.....	4	25
Lumber trucks.....	5	20
Lumber wagons.....	5	20

¹ Life of operation.

² If life of operation unknown.

